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AUTHORIZATION HEARINGS FOR DOE ENVIRONMENTAL PROGRAMS IN FY 1990

HEARINGS

BEFORE THE

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH AND ENVIRONMENT

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

APRIL 6, 27, 1989

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AUTHORIZATION HEARINGS FOR DOE ENVIRONMENTAL PROGRAMS IN FY 1990

THURSDAY, APRIL 6, 1989

U.S. House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Natural Resources, Agriculture
Research and Environment,
Washington, D.C.

The subcommittee met at 9:35 a.m. in Room 2325, Rayburn House Office Building; Honorable James H. Scheuer, chairman, presiding.

Present: Representatives Scheuer, Tanner, Wolpe, Skaggs, Schneider, and Morrison.

Also present: Eileen Lee, Science Consultant; Michael Rodemeyer, Staff Director and Counsel; and Wesley Warren, Republican Technical Consultant.

Mr. Scheuer. Good morning. The Subcommittee on Natural Resources, Agriculture Research and Environment will come to order. Today we will consider the fiscal year 1990 budget, the request by the Biological and Environmental Research Program within the Department of Energy, the DOE.

This program encompasses a wide variety of research projects ranging from the potential for microbial management of hazardous wastes to the epidemiology of radiation exposure to human genetics. DOE was the first federal agency to recognize the value of undertaking a large-scale research project to decipher the human genetic profile. The Department's historical strength in managing large-scale multidisciplinary projects and its system of National Laboratories make the Department uniquely suited to play a major role in the coordinated Federal Genome Research Project.

Although DOE has requested $27.6 million for this activity in fiscal year 1990, an increase of 58 percent over the current funding level, scientists working on the project say that this amount is barely adequate to meet the goals which the Department's own advisory committee has laid out.

A second key area within the Office of Health and Environmental Research is the Nuclear Medicine Research Program. The application of radiation for the benefit of human health has always been a part of the DOE mission and, as such, the Department has been the leading source of funding for nuclear medicine research.

Although $37.645 million has been requested for this program in fiscal 1990, scientists are concerned that this modest increase falls far short of the investment needed to fulfill the potential inherent in this technology. Advances in imaging and diagnostic techniques made possible through nuclear medicine have measurably improved the quality of health care provided to patients, and in some cases have actually provided a more sensitive and lower cost alternative to conventional medical techniques.

The exciting developments made through the Biological and Environmental Research Program, as evidenced by breakthroughs in human genetics and nuclear medicine alike, underscore the importance of a strong federal commitment to the support of this very worthwhile and important program.

I would like to recognize with great pleasure a newcomer to our committee but a senior Member of Congress, Congressman Howard Wolpe of Michigan.

Mr. WOLPE. Thank you very much, Mr. Chairman. I have no opening remarks. I'm delighted to return to this committee and look forward to receiving the testimony of our witnesses this morning.

Mr. SCHEUER. Thank you very much, Congressman.

Today our first witness will be Dr. Robert O. Hunter, Director, Office of Energy Research of DOE. We are delighted to have you here, Dr. Hunter. Why don't you take such time as you may need, five to ten minutes, and chat with us, hopefully informally. Your full prepared testimony will be printed in the record and after you are finished, I'm sure we will have some questions for you.

STATEMENT OF DR. ROBERT O. HUNTER, DIRECTOR, OFFICE OF ENERGY RESEARCH, U.S. DEPARTMENT OF ENERGY.

Dr. HUNTER. Thank you, sir. It is a great pleasure to be before you here today for the first time. I am here today to present to you the Department of Energy's FY 1990 budget request for the Biological and Environmental Research Program. You have my written testimony, and then I would just like to make a few brief summary remarks.

As you know, in this program area there are many exciting and vital programs. Today I would just like to summarize three highlights that I think may be of interest to you in terms of what we see as emerging trends in critical areas in the program.

The first is the emergence of physical means for application on the microscopic level for molecular and biophysical research. This year we obtained the first direct image of unaltered DNA. This was done with the scanning tunneling microscope, by a team from Lawrence Berkeley Laboratory and Lawrence Livermore National Laboratory. The ramifications of this are not yet fully understood, but it raises the possibility of direct observation of the sequences in DNA and larger structures as well, as a means of physical manipulation of larger structures. This, for example, could have a very significant application in the sequencing program for the human genome.

Other observations with synchrotron light sources herald extension of x-ray imaging and observation to very short times and high resolution as well. This gives us the potential for being able to watch these microscopic structures and what goes on there in real time and in situ eventually.

These activities point towards the equivalent of the various imaging methods developed in a nuclear medicine program for the microscopic realm, and the Office of Energy Research will be examining these possibilities in detail.

The second area is global change. The heightened interest in the effect of greenhouse gas emissions is of crucial importance. We will emphasize searching for and demonstrating quantitative links between the emission of such gases and the ensuing climate change. Provision of this data in theory is crucial to our evaluation of policy and, despite the difficulty, must be approached now from the most basic perspective. We are seeking widespread involvement from universities, industry, and National Laboratories in our programs, and solicit proposals on how best to scientifically establish such links.

The third area is related to radiation effects and control. Two major topics are epidemiological studies of DOE workers and nuclear waste remediation. We are working towards consolidation of worker records and data bases in examining our policies of external access to such records. It is very important that the effect of radiation be well documented and understood and generally accepted.

The Department of Energy records and studies have been a mainstay of the historic development of this topic, and we will continue and supplement the ongoing worker studies and data collection.

The remediation of the waste problems in the Department must be accomplished in accordance with protecting the safety of the workers and the public. Also, the expense of such activities is a major concern. We are working with the rest of the Department to ensure that our basic research and technology development are structured to provide improved capabilities of both characterization and control, and particularly at the moment are participating in the preparation of an overall departmental plan.

The laboratories and work performed in this office and under these programs are an integral part of the Department-wide effort. I look forward to working with you on these and other topics of such importance to the nation. I would be happy to answer any questions.

[The prepared statement of Dr. Robert O. Hunter follows.]

Statement of Robert O. Hunter

Director

Office of Energy Research

Department of Energy

before the

Subcommittee on Natural Resources, Agriculture Research
and Environment

of the

House Science, Space and Technology Committee

April 6, 1989

Mr. Chairman and Members of the Subcommittee:

It is a pleasure to appear here today to present the FY 1990 budget request for the Biological and Environmental Research (BER) program. This program develops the knowledge needed to identify, understand, and anticipate the long-term health and environmental consequences of energy use and development. Another objective of the program is to use the Department's unique scientific and technological capabilities to solve major scientific problems in medicine and biology.

To achieve these objectives, the BER program supports research in a number of areas, including biology and life sciences; nuclear medicine; environmental sciences, including carbon dioxide and global change-related research; as well as research to develop advanced measurement techniques used in research throughout the program. The FY 1990 budget request for BER is $271.4 million (Table 1). Funding by research area is shown in Table 2. Of that amount, $255.4 million is for Operating Expenses, $12.5 is for Capital Equipment, and $3.5 million is for Construction. I would like to comment on each of the research areas provided for in this request.

The biological research carried out under the Health Effects activity is aimed at providing a sound data base for evaluating human health risks, such as cancer and genetic effects, that could result from chronic, low-dose exposures to energy-related environmental agents, such as ionizing radiation and toxic chemicals. This research includes epidemiological, laboratory animal, cellular, and molecular level studies. The FY 1990 request of $72.2 million

Table 1
Energy Supply R&D
Biological and Environmental Research
Budget Authority
($ in millions)

	FY 1988	FY 1989	FY 1990 Request
Operating Expenses	$202.4	$225.0	$255.4
Capital Equipment	8.5	9.0	12.5
Construction	56.2	23.5	3.5
Total	$267.1	$257.5	$271.4

Table 2
Energy Supply R&D
Biological and Environmental Research
Budget Authority
($ in Millions)

	FY 1988	FY 1989	FY 1990 Request
Operating Expenses			
Late Effects on Health & Environment of Energy Development and Use			
Analytical Technology	$ 15.2	$ 14.8	$ 16.2
Environmental Research	31.1	36.6	43.6
Health Effects	66.2	69.3	72.2
General Life Sciences	38.4	46.1	60.4
Medical Applications			
Medical Applications	24.1	30.2	32.3
Boron Neutron Capture Therapy at INEL	9.8	6.4	5.3
Carbon Dioxide Research	13.6	17.6	20.8
Program Direction	4.0	4.0	4.6
Subtotal	$202.4	$225.0	$255.4
Capital Equipment	8.5	9.0	12.5
Construction	56.2	23.5	3.5
Total	$267.1	$257.5	$271.4

will provide for increased emphasis on molecular-level studies and research to correlate the relationships between exposure to chemicals or radiation and the consequent biological response. The FY 1990 request will also allow us to extend ongoing health surveillance studies of DOE workers to additional facilities. Research in FY 1990 will emphasize chemical and physical characterization of potentially significant DNA damage from high linear energy transfer radiation, such as alpha and neutron radiation.

Our growing knowledge in the Health Effects area will help us to better understand such important topics as the possible hazards of indoor radon exposure. The radon research program was begun in 1987 to study this major national public health concern. Now composed of 60 projects carried out at various academic institutions and national laboratories, the program will continue to emphasize the basic scientific research needed to understand and predict the health risk related to exposure to indoor radon. This research includes measuring the exposure to radon more accurately, better defining health risk estimates, and determining the role of radon exposure in combination with smoking in causing lung cancer.

The FY 1990 request for General Life Sciences research of $60.4 million will emphasize molecular and cellular studies to examine how key biological processes operate. With this knowledge, researchers can learn more about how physical and chemical agents affect living processes. The research also identifies early indicators of biological damage, teaches us how cells repair themselves, and leads to new techniques for analyzing biological damage. Ultimately, we hope to understand the basis for individual sensitivity to radiation and environmental chemicals, and to have the technology and data base to define risks and allow the establishment of improved health protection standards.

In FY 1990, a major focus in General Life Sciences research will be in molecular genetics to reveal DNA damage and repair mechanisms and to understand the human genome--the complete set of genetic instructions that make a human being. The Department's human genome effort is focused on developing new instrumentation and methodologies that will make such research far less costly to perform per fragment of DNA identified, as well as far less labor intensive. New insight is likely to come from a recent achievement by BER-supported investigators at the Massachusetts Institute of Technology. The new technology developed there permits production of many copies of damaged DNA, resulting in the capability to rapidly detect mutational changes with an error rate of one in a billion, and thus provides unprecedented sensitivity in quantifying DNA damage in people exposed to hazardous chemicals and radiation.

One important byproduct that results from all the areas of BER research is the development of instrumentation. During the early stages of science, observation with available instruments is usually sufficient. However, at some point, it becomes necessary to measure events that have not been measured before. New technologies often result in new, more efficient, or more cost effective instruments that find applications outside the original thrust of the research. For example, the flow cytometer, developed initially to sort and count blood cells, has been improved progressively to the point where it now quickly isolates relatively pure samples of each of the individual chromosomes, thus, providing important technologies for the human genome project. In another significant advance, a team of scientists from the Lawrence Livermore National Laboratory and the Lawrence Berkeley Laboratory has used the scanning tunneling microscope to obtain the first direct images of unaltered double-stranded DNA. Extensions of this work could have major ramifications for molecular biology and research on biological structures.

Coordination of the human genome research and technical activities between DOE and the National Institutes of Health was formalized in a 1988 Memorandum of Understanding, which provides for a joint advisory committee and an interagency working group. Research on the human genome at Los Alamos and Lawrence Livermore National Laboratories and Lawrence Berkeley Laboratory will build upon the considerable progress already made in developing the intellectual and physical resources (including engineering, computational and biomedical expertise) for genome analysis. For example, the molecular nature of chromosome ends and centers has been identified, contributing substantially to our ability to map chromosomes. In addition, libraries of cloned DNA have been prepared, and an automated system is now rapidly processing the DNA in one chromosome-mapping effort. The FY 1990 request of $27.6 million for the genome activity, up from $17.5 million in FY 1989, provides for an expanded effort which will include initiating physical mapping efforts for chromosomes where this is not already underway, testing new approaches for mapping, and providing necessary support to DOE Human Genome Centers and other large interdisciplinary efforts. Pilot sequencing projects will also be initiated to evaluate and compare new sequencing technologies. The proposed level of effort will enable the Department to maintain its momentum in the area of developing new tools and methodologies which will greatly increase the pace and lower the cost for mapping and sequencing the human genome.

The FY 1990 request for the Analytical Technology activity is $16.2 million. This request will provide for research directed at developing new and more sensitive instruments to make physical, chemical and biological measurements of energy-related emissions. These instruments will also assist scientists in measuring human exposure and biological response to those emissions.

Over the years, the Department's Medical Applications research has been at the forefront of important medical discoveries and has provided information that has led to the widespread use of nuclear technology in modern clinical and laboratory medicine, opening avenues of diagnosis and treatment that otherwise would not have been available. The FY 1990 budget request of $37.6 million will allow research to continue on the development of new radioisotopes, clinical procedures, and instrumentation.

The effort in boron neutron capture therapy (BNCT) has been greatly expanded in the last two years. An effort is currently under way to develop BNCT for the treatment of brain tumors and melanomas. This method is based on the fact that the reaction of an isotope of boron with neutrons produces a nuclear reaction that provides a form of highly localized radiation. When used with boron compounds that selectively concentrate in tumors, this method may make it possible to deliver therapeutic doses of radiation to a tumor with minimal effects on adjacent healthy tissues. Ongoing laboratory research is aimed at providing the data base necessary to determine whether this type of therapy can reasonably be expected to be successful with patients.

The development and use of radiopharmaceuticals in metabolic studies is another major aspect of the program. Radiopharmaceuticals are radioactively labeled compounds that concentrate in certain body organs and can be imaged with sensitive radiation detectors to make the body's internal organs visible to medical diagnosticians. Changes in the spatial and temporal distributions of the labeled substances allow diagnosis to be made without invasive procedures such as biopsy. Radiopharmaceutical research emphasizes studies of brain and heart metabolism, but also contributes to diagnosis and therapy involving other organs. The FY 1990 request also provides for clinical feasibility research which includes testing of new radiopharmaceuticals in animals and, subsequently, in selected patients. This effort evaluates methods for studying, diagnosing, and treating diseases such as cardiopulmonary disease, mental disorders, cancer, and metabolic disorders.

Research will also continue in FY 1990 on the advanced instrumentation required to diagnose and treat patients using nuclear medicine. This research emphasizes advanced detector studies, improved resolution of Positron Emission Tomography (PET) and other imaging techniques, and innovative applications of energy-related technology for noninvasively studying the functioning and condition of internal organs. Recently, in this area, the development of a new and unique PET system has been completed. PET imaging is a method for studying the metabolism of radioactively labeled substances in selected parts of the body by tracking the radioactivity of the label. The new system significantly improves the quality of the computed images and makes it possible to acquire an essentially three-dimensional picture of an area as large as a human heart. This new PET system will be used to study blood flow in the heart and may be able to detect coronary artery disease before clinical symptoms appear. It can also help to diagnose the focal points in the brain that cause seizures in children and distinguish among the different kinds of mental degenerative diseases. In FY 1990, research will continue to develop a technique called high field nuclear magnetic resonance spectroscopy for studying metabolic functions in organs. If successful, it would allow the diagnosis of metabolic disorders of organs such as epilepsy and dementias. Research will also focus on using synchrotron radiation for a safer coronary angiography test which would be used to study the development of atherosclerosis before it has become severe enough to cause a heart attack.

The FY 1990 budget request for Environmental Research is $43.6 million. Another $20.8 million in Operating Expenses and 1.5 million in Capital Equipment is requested for the Carbon Dioxide research activity. Together, these research activities provide information needed to address a number of important issues, including acid rain, global climate processes, the resiliency of ecosystems and marine coastal areas to energy activities, and management of energy and weapons related radiation wastes.

The request for Environmental Research will provide for continued research aimed at determining how energy-related agents move through and are changed by the atmosphere, oceanic and terrestrial ecosystems, and how they ultimately affect humans. Scientists are also looking at how the environment itself may be affected and how negative effects can be mitigated.

An increased research activity in FY 1990 will be aimed at developing basic scientific theories about the interrelationships between atmospheric and terrestrial systems (e.g., plants, water, soil, and air). In the future, we plan to test these theories in natural environments, primarily at the Department's National Environmental Research Parks. The information gained through a combination of theory and experiments will contribute to a better understanding of global change processes.

An ongoing effort in subsurface sciences will be expanded from $7.3 million to $11.8 million in FY 1990 to develop a better research base for cost-effective management and remediation of contamination from the Department's energy- and weapons-related project wastes. The recent discovery by BER-supported researchers of microbial communities over 1700 feet deep within the earth has changed scientific thinking about microbial abundance and diversity at such depths. Previously, such diversity and abundance was believed to be common only at depths of tens of feet. This discovery may contribute to cost effective in situ cleanup of deep groundwater contamination. Technology transfer of the newly discovered microorganisms to the pharmaceutical industry is already underway. Work supported in FY 1990 will focus on understanding of the factors that influence the mobility of mixed wastes through the soil so that shallow, low-level waste burial sites can be operated more safely and cost effectively.

Another major area of emphasis in FY 1990 relates to carbon dioxide and the greenhouse effect which, linked to global climate change, has become a national and international science and energy policy issue. A major component of the global change activity is the Carbon Dioxide program, which I previously mentioned. It is continuing to develop sound, quantitative information about atmospheric CO_2 and other energy emissions and their effect on climate and earth resources. We must improve our understanding of the cause and effect relationships between CO_2 concentrations and global, regional, and seasonal warming to support energy policy recommendations. This program is focused on the scientific aspects of the problem.

The FY 1990 budget request will support research aimed at improving our knowledge base in the above areas, with particular emphasis on the key issue of determining the quantitative links between the rise in concentrations of greenhouse gases in the atmosphere and global warming. Specifically, we must have a better understanding of how climate is changing and whether those changes are related to atmospheric greenhouse gases. Substantial improvement is needed in the way oceans and clouds are portrayed in climate models in order to accurately predict changes. Finally, we need to collect data to evaluate the primary effects of both CO_2 and climate change on biological systems as a whole.

The program will seek multidisciplinary input from the scientific community to gain a broad perspective. Climate change research activities throughout the Department are being coordinated by Energy Research, with interagency coordination being implemented through the Committee on Earth Sciences of the

Federal Coordinating Council for Science, Engineering, and Technology. International activities are being coordinated through such organizations as the Intergovernmental Panel on Climate Change.

The FY 1990 request for Program Direction is $4.6 million. These funds are required to pay for the personnel costs of 55 full-time equivalents to direct, manage, and support BER's multidisciplinary research efforts.

The FY 1990 BER budget request for Capital Equipment and Construction is $16.0 million. This includes $12.5 million for Capital Equipment and $3.5 million for Construction. The Capital Equipment request supports replacement of deteriorated and obsolete equipment at the laboratories as well as acquisition of new, state-of-the-art equipment, particularly for the carbon dioxide and subsurface sciences activities. The General Plant Projects that fall under the Construction request are necessary to keep the general plant of the laboratories (e.g., buildings, roads and utilities) in good operating condition.

That concludes my statement. I would be happy to answer any questions.

Mr. **Scheuer**. Thank you very much.

Congressman Sid Morrison of Washington has joined us. Sid, do you have any opening statement you would like to make?

Mr. **Morrison**. No, Mr. Chairman. I am here because of a very vital interest in the program that you're looking at this morning.

Mr. **Scheuer**. Great.

Mr. **Morrison**. Thank you.

Mr. **Scheuer**. Very good.

Howard, would you like to commence the questioning?

Mr. **Wolpe**. No, Mr. Chairman. Please proceed.

Mr. **Scheuer**. Sid, do you have any questions you would like to ask the witness?

Mr. **Morrison**. I'm sorry to get here just to catch the tail end of your testimony. I was reading through, and of course you are saying all the things we want to hear, partially because of the importance from my perspective of such things as the Environmental Center of Excellence.

I am wondering, in the Reagan budget that was proposed and supported then by the Bush Administration, some funding for both the Environmental Center at Hanford as well as the Molecular Science Center, are those two tied together in any way? Do you see that some of the answers maybe to finding lower cost ways of dealing with both toxic and radioactive waste materials are going back to the molecular structure and seeing what can be done to render those benign?

Dr. **Hunter**. Let me comment on what we see as the scientific linkage and eventually the utility of having those activities co-located. As you know, we have a substantial and ongoing program in subsurface research and things of that nature that are already existing at Pacific Northwest Laboratory.

The Environmental Center of Excellence was to combine those and the molecular sciences research activities to help give us a real focus for basic research at Pacific Northwest's laboratories. The connection between the basic research and the eventual application in some areas is direct and in some areas is not quite so direct.

For the basic research in the Molecular Sciences Center, we have asked that high quality be the number one criterion for support of that research. But to give you an example of the coupling, in order to develop models for how materials chemically change and evolve in a mixed fluid and solid environment, one thing you would do with a complex contaminant molecule which, say, entered from some contaminant source, is it will undergo change on the microscopic particles that are in that environment. And in order to model that properly, you need to develop the tools to tell what happens to a particular contaminant molecule as it evolves in terms of actual processes on the surface. In other words, on the surface of the solid particles.

And when it's on the surface, it changes structure some. Its bonding changes. You have long complicated molecules and you will see changes, for example, in charge transfer excitations, so you can use those excitations to follow the reaction rates of that particular molecule as it evolves and moves through this heterogeneous mixture. So in that way, you can eventually develop a model for, as you put the contaminant in, how it evolves through to the eventual species that you actually see, and you can predict then how it would evolve in the future in situ, in the regions where you see it spread out.

So it's not just the transport of it that we are interested in; it is also the chemical evolution. And by studying the molecular science, if you will, of how that molecule absorbs light and how the change of the absorption on solid surfaces is different from the absorption in the gas phase and what the absorption looks like in a liquid phase, they can and are moving towards building laboratory models in which they actually see the change of the molecule and, in addition, they can then measure the rates as to what actually happens on the various types of surface that you encounter in the environment.

So it's that kind of connection that we see as providing this very valuable information towards an eventual capability of knowing if you release a certain contaminant into a certain environment, not only the transport of it but the rates at which it evolves into other species and things of that nature. So we see the molecular end of it as being an important component for the Integrated Research Program.

Mr. **Morrison**. I can assure everyone that the new Secretary of Energy is counting greatly, Mr. Chairman, on the efforts that we are reviewing this morning to save dramatic quantities of money in the new commitments that are being made on environmental restoration among the numerous Department of Energy sites around the United States.

Is that accurate, Doctor?

Dr. **Hunter**. Yes. He has stated in the course of his preparation of his plan that will come before Congress I believe in August, we have two parts to that—one is new technologies to help reduce the cost of that remediation, and there are several specific initiatives there that he has outlined—the use of robotics, for example.

The second part, though, and it is carefully integrated with the development of that plan, is the use of the National Laboratories and others, from a basic viewpoint to characterize the severity of contamination and what will happen to it in the future and things of that nature. And he has made it quite clear that he's counting very heavily on those kinds of involvements and activities. And as I said in my comments, we are participating in an integrated development of that plan in the Department at the moment.

I would add that in addition, in another category of energy research, we have undertaken an initiative in underground imaging to apply advanced phased arrays and data processing to try to be able to non-invasively determine substructure from the surface so that we can hopefully apply that as well.

So we see many technological avenues that will be possible to help us with the advanced remediation and characterization. And, as you know, there are already techniques being developed, such as in situ vitrification, things of that sort, including work at Hanford, to help with that matter. So we are extremely conscious, and he has stated publicly and inside the Department that advanced technology is going to be a major component of his way of dealing with that problem in the most efficacious and least expensive fashion.

Mr. **Morrison**. In response to a question of mine earlier this week, the Admiral indicated that not only were they counting on it; that they were willing to invest in it. But unfortunately the timing on his plan to come out later this summer doesn't probably really catch us in the right part of the budget cycle. So it's important from your point of view that we retain funding, in fact do everything that we can with it in these areas, including work such as at Pacific Northwest Laboratories.

Dr. **Hunter**. Well, even prior to the initiation of this particular activity, in the plan we had asked Mr. Duke, now associated with the laboratory, to help us in putting together how to handle the waste remediation from a basic research viewpoint; in other words, ensure that the basic research that we're doing is appropriate to this problem and that we are properly organized in the laboratory complex and the industry complex to deal with it.

So those activities are going on. In addition, they will be closely coupled into the development of this plan. So it may not be, I think, in the most advantageous situation with regard to the funding cycle, but until the evolution of the waste problem in the Department and the priority that it has today had taken place, I don't think you would have seen as much interest placed on that issue.

But we are starting to look at the issue of how to make sure that our programs in this program element and others were properly structured from the basic research viewpoint and had involved Pacific Northwest Laboratory as a major element of developing that plan and helping us carry it out.

Mr. **Morrison**. I have certainly been pleased with the quality I've sensed there. Does the Department hold them in high regard?

Dr. **Hunter**. The Pacific Northwest Laboratory?

Mr. **Morrison**. Yes.

Dr. **Hunter**. Yes. And as I said, in the ongoing programs that we have in the subsurface research and things of that nature, we think it's of the highest quality, very good quality. We look to it to provide a source of manpower, if you will, to help us with the rest of the complex, both characterization and remediation.

The Environmental Center of Excellence, as you know, was designated in large measure because we wanted a place to handle the basic research and serve as a focal point for the waste remediation problem in the entire complex.

In the Molecular Sciences Research Center, we have now with the steps that have been taken there, set up to involve very high quality people both in the management and in the advisory committees that you have. We feel that you have a very high quality program. We have reviewed that program before and we will continue to review it because it is a newly formed program, but we look forward to having a real Center of Excellence there that lets us both have a very high quality basic research program for the laboratory and for this problem and, as well, to serve as a source of manpower and lead in, if you will, on the characterization or remediation side for the problems that the complex faces.

Mr. **Morrison**. Thank you very much.

Mr. Chairman, in case you hadn't made note of it, Dr. Hunter—the family makes a contribution to our colleagues here. His brother, Duncan Hunter, our fine colleague from California.

I have a sensitivity to this, because I have an older brother who got the brains in the family. He's a PhD from MIT and that sort of thing. And Duncan is probably sort of in the same position, but we love him anyway, don't we?

Dr. **Hunter**. Actually, it works the other way. If I do poorly in these various hearings, I think he'll disown me.

Mr. **Scheuer**. We have been joined by John Tanner. Do you have any questions now?

Mr. **Tanner**. Not at this time, Mr. Chairman. Thank you.

Mr. **Scheuer**. Dr. Hunter, the Office of Health and Environmental Research, which has direct oversight over the Biological and Environmental Research Program, has been without a Director for two years now. That spans two administrations, and I can't fault the current administration for the whole two-year gap.

Can you tell us why there has been this kind of a delay in filling what is really a very essential and critical position?

Dr. **Hunter**. I can't tell you prior to my involvement. I can say that when I came into the office last August, they were certainly aware of that. They had conducted searches for candidates. It was clear to me it was a position of some importance and Dr. Wood, who was the Acting Director, and I think a very fine and well-qualified person for it, had basically stated that he did not want to serve in that position. On the other hand, I've noted that his performance has been extremely good on a variety of subjects that I've dealt with him, so I am confident in the management as it is going forward.

I did undertake to offer the position—and actually did—to two qualified persons, both of whom declined it, largely having to do, at least in one case, with what I view as financial reasons; that is, the disparity between the money they would be getting in that position and what they were getting at present. And I am now in the process of searching further for a Director of that office.

But, in response to your question, we understand it's a very important position. We had conducted a search. We did offer the position. It was declined. I feel that Dr. Wood has been serving in actually a superb fashion in the interim. He's the only one to serve in that position as the head in the interim. And having worked on a number of topics closely with him during that period of time, I think it is being very well handled.

But we are continuing to look for candidates for that position and will make every effort to ensure that despite the pay disparities we might see and things of that sort, that we do fill it as quickly as we can with a highly qualified candidate.

Mr. **Scheuer**. Do you have a timetable you can give us? When can we expect an announcement?

Dr. **Hunter**. No, sir, I don't.

Mr. **Scheuer**. Let me say, Dr. Hunter, with all respect—well, let me ask you, what was the reason that this chap gave for not wanting to become full Director?

Well, we'll ask him later on. Maybe we'll ask him now. May we ask you, Dr. Wood, what is your reason for not wanting to assume the Directorship? Why don't you step up to the table just for this question, and then we'll release you.

And if there are any personal reasons involving family or other personal considerations, they are really none of our business and I wouldn't pry into that. What are your professional reasons for not wanting to assume the Directorship?

Dr. **Wood**. I've thought about that, obviously, very, very carefully. I did that a year and a half ago when I was first asked to step in in the interim.

Looking at myself, I just felt that my own personal preference was for different types of challenges and responsibilities, more those responsibilities that I had had in my responsibility as Division Director there. And I felt that it would be best to find individuals that had been more actively involved, more recently involved in scientific research because we were moving into new directions, new areas, and if it were possible to find someone with more immediate research experience and background, who relished the challenge of directing a major program like this, that that would be preferable.

As I said before, I was perfectly happy with the responsibilities that I had.

Mr. **Scheuer**. All right. Well, thank you very much. We'll look forward to your testimony in a few minutes.

Dr. Hunter, it's perfectly obvious that Dr. Wood, from your statement and what we know about him and what we know about his record, has done a superb job in the position which he is filing now, and I regret that being permanent Director doesn't fit his personal priority judgments as to how he wants his career line to develop. You all have to make those judgments, and I'm sure he has excellent reasons for having made it.

That being said, don't you feel that it's a sort of an unhealthy condition for a chap, however superbly qualified and however excellent a job he's doing, who has made it clear that he doesn't want to continue in that job as the permanent Director, isn't it an unhealthy position? We can tolerate it over the short pull, but over the middle range and over the long range, isn't that a basically unsatisfactory situation?

Dr. **Hunter**. Yes, sir; it is.

Mr. **Scheuer**. And shouldn't you be really exercising very diligent efforts to find a successor?

Dr. **Hunter**. Yes, sir; I should. And I believe I have. Again, we offered the position to two people, both of whom declined it and who had responded to our various methods of formal advertising.

Mr. **Scheuer**. May I ask, without inquiring as to their identities, two people you thought were eminently qualified, why did they turn it down?

Dr. **Hunter**. Well, I can speak to the reasons that I understood them to give. And they were, one, that they were making—and one of the parties was in another part of the government where they were making substantially more monies.

Mr. **Scheuer**. In government?

Dr. **Hunter**. In government. And that was because they were an M.D. and they receive an M.D. allowance of an extra, approximately—I don't know the exact numbers, sir—$20,000 a year in their position, and they had a contract for a fixed period of time.

There were strong complications where if they joined the Department, this position did not clearly warrant an M.D. designation. I spent a fair amount of time with our administrative people, trying to see if we could get an exception, for example.

What it ended up with was they had to cancel their contract with an agency which could have cost them money. There were clauses in the contract apparently where it could have cost them monies that had already accrued to them, to come over and take the position at a substantially lesser salary. And our side felt that it was simply not appropriate from the way that the staffing and the allocation of the programs were concerned, to obtain a new designation for the allocation of monies for that particular Directorship, when in the past the fact that the person had been an M.D. was not a criterion for filling the position.

So I spent I would say roughly two months exploring all the variations on those topics, if you will, about the possibility of getting our position readjusted, about the possibility of how to deal with their situation and, in the end, it was clear it was not going to work out. It had gone on a while, we weren't able to resolve it quickly, and the party declined to consider it further. So that was the reason I was given there.

The second party, although I considered them qualified and we had conducted an extensive search, felt that the breadth of the programs were beyond what they wanted to do. In other words, they felt that it was not appropriate, having looked in detail at projects and become familiar with them, it was not appropriate to their desires or qualifications at the moment to take on the management of that office.

I am, and prior to that, I have initiated a number of informal searches. I do have a candidate, a person who has indicated some interest now, but we also have to comply with all the formal requirements. We are under various regulations and restrictions about advertising the position, which is a lengthy process, and evaluations. All I can tell you, sir, it was clear to me that we needed to get it resolved. Dr. Wood has served, I think again, superbly, but did indicate when I very first came in, it was made clear to me he did not want to be the permanent person, and I couldn't agree with you more.

We are moving forward. I have a candidate for at least taking on the job for a fair period of time, and I will try to work through that as quickly as I can and develop additional candidates.

We developed other candidates, elicited interests from mainly academic groups outside, and their view of the position is somewhat different. You can get parties interested because of the challenges involved, which I think is the best way of recruiting someone, but the monetary inducement to join is quite a bit different from what they can get in an equivalent position outside. In other words, they have to be willing to undertake fairly severe sacrifices financially to take on the position, many of them.

Mr. SCHEUER. What kind of cuts are you talking about? What kind of cuts are you in effect asking these people to take?

Dr. HUNTER. Well, there was one fellow who was Vice President of Research at a bioengineering company, and I didn't inquire into the details, but I'd guess it's a factor of 2 or 3.

Mr. **Scheuer**. In other words, you're asking him to take half to a third of what he's getting?

Dr. **Hunter**. On that order. Yes, sir.

Mr. **Scheuer**. Well, that's an extraordinarily difficult thing.

Dr. **Hunter**. That's what I'm trying to say. I believe that there are ways to recruit for the position. I do have a person now that is interested, has indicated an interest to me. He's head of a biophysics, actually a molecular biology department, and I am pursuing that as fast as I can.

Mr. **Scheuer**. Look, Dr. Hunter, I don't want to beat this horse into the ground. It's obvious that you are making good faith efforts. It's obvious that you understand that the research community is concerned about the symbolism here of not having a Director for two years, and that this represents the level of priority accorded to these activities, the activities of this office by the Department.

It's perfectly obvious to me that you are aware of all this, that you are making good faith efforts, and that you have expended a considerable amount of time already. It is obvious you are making bona fide efforts to remedy this situation and I appreciate that and I thank you for that, and I understand the problem that you're facing. It is not a simple problem, recruiting high quality scientific personnel to government at the prevailing salary levels, and we can only hope that you will continue to work at it diligently and come up with an answer. And we hope you will inform us as soon as you have achieved some kind of an answer.

Dr. **Hunter**. I certainly will, sir. The only reason about giving you a definite date is, given those constraints—

Mr. **Scheuer**. I understand. You're not in a position to do it.

Dr. **Hunter**.—I'm just not in a position to do it.

Mr. **Scheuer**. No, you are not. And I appreciate the effort that you are obviously putting in.

As I mentioned in my opening remarks, there is concern expressed by the representatives that we will hear, of the national labs, that the amount of money the Department has requested for Human Genome Initiatives, the whole program of delving into the mysteries of the human genome, are just marginally adequate, barely adequate to meet this ambitious program that was outlined by a DOE advisory committee some two years ago as I recall.

Is the Department reconsidering its role? Are they having any sober second thoughts about their role? Are they uncomfortable about coordinating their human genome research with the NIH? You are spending about $25 million; the NIH is spending $100 million. Does this pose any problems of leadership, of concern? How do we achieve some kind of an unlocking of the bolt to liberate you and all your talents and energies, you and your Department, to get at this incredibly important program in a solid productive partnership with NIH in a way that will be cost-effective, that will be human resource effective, and will bring us close to this very important role of unlocking the mysteries of the human genome?

What more tinkering do we have to do? How do we have to massage the financial arrangements or any other arrangements to really liberate you?

Dr. **Hunter**. Let me speak to that, sir. In the first place, from my viewpoint, as I tried to indicate in my opening comments, the

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issue here is broader than just the human genome. I think that we're going to see a convergence where physical instrumentation will give us whole new ways of looking at what goes on in a molecular sense in structural biology, genome as well. We're going to see manipulation on a microscopic scale mechanically. There will be enormous advances, like the surface tunneling microscope that not only lets you look at angstrom type structures, but will lead to manipulation directly of microscopic type structures instead of relying on the conventional chemical means, the biochemical means that have been developed over the years primarily.

So I am extremely enthusiastic. One of my first acts when I came into the office was to ask them to look at what I called microimaging with x-rays, neutrons, anything, coherent electrons, because our office builds these large sophisticated facilities. Our National Laboratories have instruments, for example, like the advanced light source under construction at Berkeley. So the objective there was to see how we could adapt those kinds of instruments in essence, in the long-term future, to these problems and they would give us an enormous advance, and not just in the genome but in other areas as well.

So we have pursued that. We are looking at it carefully. We've asked people to come in with proposals on how to do it and whatnot. So I couldn't agree with you more than I think we are seeing an enormous opportunity in the microscopic way of adapting physics and chemistry to this problem right now, and we are moving accordingly.

Now, with regard to the details of the particular genome program in the Department of Energy, the program has seen a very substantial increase this year, I believe roughly $10 million. So we think very highly of the program and asked for that increase and obtained it at a time when the rest of our budget in the Department did not grow at nearly that rate. So we have seen an increase there.

Now, with regard to how best do you make progress in an area like the genome, this image, the surface tunneling microscope image of DNA, the first one ever taken which was a direct image of an unaltered DNA in its natural state, not reconstructed from x-ray to fraction patterns or anything else, something I consider an enormous advance, was actually made on very little money. It was made with a small group, working very hard in a dedicated fashion on that topic, and was not a mainline part of the program.

In fact, I was astounded. When I first came in I said, we want to look for physical imaging ways of doing this, and I did not even encourage the surface tunneling area at all. And then a few months later, this picture showed up, which in the long term will have enormous ramifications.

So the amounts of money involved were small. It was the inventiveness of the groups, and it was their stamina, if you will, and their working on this problem from a variety of directions that made an enormous difference.

So in the area of invention of new techniques and technologies, there is a lot of other technology out there. It is associated with physics research going on in the labs where there is an enormous amount of money being spent, and we are spending a great deal of money, for example, on our x-ray rings.

Now, let me talk in particular about the genome program as it is characterized with regard to NIH and the way that the DOE and the NIH have interacted on that program, which I gather was the central thrust of your question.

Mr. SCHEUER. Correct. How can we improve the interaction, and do any changes have to be made in the funding arrangements or the institutional arrangements to maximize the cost effectiveness?

Dr. HUNTER. When I first came in, I had a meeting with Dr. Wyngaarden and his people. We were going through this MOU. I asked him—it was a long discussion—but the central questions that I asked him were, do you use our laboratories? Does the NIH, do they fund people in the Department of Energy laboratories? Do they sponsor work in DOE facilities?

In other words, I was trying to understand if there were any barriers to that kind of interaction. And he said no, absolutely not. In fact, at the time it turned out that they had designated some NSF activities directly at the laboratories. I called Dr. Wyngaarden yesterday just to make sure about this, because I hadn't heard these questions about the increase, and I said, is there any restriction on the use of the monies that I've heard being allocated for this to use in our facilities? In other words, are there any institutional barriers between the most efficacious use for the entire amount of money the government spends as a whole?

And his answer to me was there was not. There were no restrictions on the use of their monies insofar as he knew, and it was certainly not the policy. You know, it was the same answer I had before. In other words, that the money that the NIH will receive for this, whatever goes through, can be competed for and worked through with DOE laboratories. So there is that part of it.

Now, the other part is the way the program fits together. How do you decide how much money the Department of Energy spends and how much money the NIH spends? We worked through a Memorandum of Understanding that was in process when I arrived and I believe was executed in October of last year, which bore on the question of how to coordinate the genome and how to make sure the program went forward, and yet independent, but that we had complementary types of efforts.

In the course of those discussions, the memorandum reflected some principles. We would set up a joint advisory committee. Both the NIH and the Office of Energy Research have advisory committees for the genome project. They have designated their individuals to serve on the joint advisory committee. They have a working group that consists of staff members they have set up. There is extensive interaction and coordination at the staff levels on the genome projects. And they have, I believe, fairly recently jointly reviewed the proposals that all the parties have received.

So what we have here is a situation where all the parties, the parties are fully cognizant of what the other party is doing. They are cooperating. We have our separate advisory groups and whatnot, but there will be—I wanted to emphasize, make sure of this from when I first came in—but there will be close cooperation between the two agencies.

Now, as for the money, we elected not to put—didn't think about it at the time—but not to put a lock-step condition on the money. How do you decide how much money which agency spends? That's not in the Memorandum of Understanding.

Mr. SCHEUER. Dr. Hunter, we understand that the National Institutes of Health have determined that they will not fund DOE genome centers. Is that your understanding?

Dr. HUNTER. I don't know what the word "genome centers" is. I can just relate to you, I've checked this twice—

Mr. SCHEUER. In other words, we have heard that they have determined and they have stated that they are not going to fund genome centers as opposed to funding individual scientists at national labs. That concerns us.

Is this their enunciated policy?

Dr. HUNTER. The policy, as enunciated to me by Dr. Wyngaarden yesterday, was that there were no restrictions on proposals or things of that nature from our facilities, the National Laboratories, for involvement in the NIH programs.

If they choose with their money not to fund bloc centers, for example—

Mr. SCHEUER. Do you mean a genome center?

Dr. HUNTER. That's what I'm asking you, sir. I'm saying if we have centers that we have designated, that they choose not to bloc fund as entire centers, from my viewpoint, unless they have received a proposal from that entire center and they deem it worthy of funding as a center, that would be appropriate.

Well, that's what I've heard, and I heard it from the head of NIH. I can check on the issue of will they fund genome centers.

Mr. SCHEUER. Who did you hear it from, Dr. Hunter?

Dr. HUNTER. Dr. Weingaarden.

Mr. SCHEUER. Well, for example, we understand that the Lawrence Berkeley Lab, which has been designated as a genome center, requested funds for the construction of a new facility to maximize the use of staff and other resources devoted to the genome project.

Now, the Department did include this request in their submission to OMB, but the President's budget does not include funds for this project. Now, if the Lawrence Berkeley Genome Center, headed by Dr. Charles Cantor, is an essential component of the DOE genome effort—and I presume if it isn't, you ought to tell us—how will you address and how can we address the Department's critical need for expanded space and facilities over the next couple of years?

Dr. HUNTER. In the first place, there's no doubt that it's an essential component. I mean Dr. Cantor, I believe, is the head of our Genome Advisory Group to my office, the Health and Environmental Research Advisory Committee on the genome part, so he is certainly an essential part of that. He is involved on both sides—

Mr. SCHEUER. Your Department did include his request for funding for space and facilities in your budget, but it was not in the budget as it finally got approved after having been scrutinized, raked over, I suppose you could say, by the OMB.

How are we going to meet his need if his group, which is a very talented and skilled group, is going to do their job when they asked for a mere $1,200,000 or something in that neighborhood, a very insignificant amount—how are we going to make sure that they have the space and facilities to enable them to fulfill their very critical role?

Dr. HUNTER. Mr. Scheuer, I can assure you that their having adequate space and facilities to fulfill their job has been a major concern of ours. We have budgetary constraints. We have a process we go through in the administration. We've seen a substantial increase in the total genome funding. We have supported these various efforts, I think, appropriately.

I believe what you have described is in fact essentially correct; that the final President's request did not include the building for their center, but we've been concerned about that and we have been examining all the alternatives. The alternatives have included, for example, modules, trailers if you will. They have included other buildings for use at LBL. In other words, we are going through those alternatives to make sure they get their housing, a place to go and have a building.

On the other hand, from my viewpoint, we have received out of LBL at the moment, and Lawrence Livermore National Laboratory, a most significant piece of work in the scanning tunneling microscope area.

So we are seeing good work come out of LBL without—I mean having this building is not the prerequisite, obviously, to seeing good work come out of LBL.

Mr. SCHEUER. Well, you are quite right. None of us up here has an edifice complex, believe me. But if space and facilities really become a significant impediment to achieving the progress we are looking for, then we have to think about the space and facilities.

Dr. HUNTER. Sir, all I'm saying to you is we have been real concerned about it. We've had discussions with them as a result of this budgetary constraint: how do we work with you to get through this, make sure you get your space, make sure we are able to go forward? Commitments have been made to people and things of that nature. We've had extensive discussions with them and will continue those. We are committed to seeing the thing work.

Mr. SCHEUER. Dr. Hunter, apparently your funding request to OMB—let me put it another way—apparently OMB approved a funding level for you significantly under what you requested. And apparently they approved a funding level for NIH substantially above their request.

Can you explain this to us or give us some explanation of how that happened or why it happened?

Dr. HUNTER. Let me just say what I know to have happened, sir. That's what I can tell you. When I asked Dr. Wyngaarden about that, he said that the NIH at the secretarial level, the HHS level, the NIH had gone forward with three major initiatives, of which the genome was one, and they had marked that as a very substantial initiative, one of their three major initiatives in the NIH that year—I believe AIDS research and low birth weight children are the other two.

Mr. SCHEUER. AIDS research, did you say?

Dr. HUNTER. Yes, sir. Something related to AIDS research and I don't know the specifics further than that. That they viewed those three things as very high priorities, and they had as a consequence singled those out and in the context of their overall budget if you will, they had gone forward with those initiatives within their internal departmental budgeting process as major initiatives. And from what I can tell in the overall administration formulation of its budget, that found favor, and there may have been substantial additions to those monies made on the grounds that the money would be very well spent; that their Department clearly viewed that as an enormous priority for them.

Now, in the case of our genome research, we went forward with a very substantial increase. We actually went back—

Mr. SCHEUER. But you didn't get it.

Dr. HUNTER. No, sir; we got the increase we asked for. We kept within the total guidelines of the budget levels that the Department was asked to comply with. And the genome received fractionally a very large increase in our budget relative to almost anything else.

Mr. SCHEUER. Dr. Hunter, let me just give you some figures, and if these are incorrect or if anything I say is incorrect, you know, I am a totally fallible human being.

As I understand it, your budget from '89 to '90 went from $17 million to $27 million. That's roughly a 58 percent increase, and by normal criteria that would be a hefty increase, although you are starting with a very small base.

Now, the NIH budget went from $27 million to $100 million, which is just about a 400 percent increase, exponentially greater than yours. Now, one gets the impression, and I might be totally misinformed and not have a clue to what is really going on, but one has the impression that DOE is getting the short end of the stick in the allocation of resources. You got a not insignificant increase, a healthy increase of $10 million, but NIH got $75 million, or $73 million.

Why is there such a disproportionate relationship between the flow of resources for genome research to NIH and to the rather paltry, by comparison, share of resources going to you?

Dr. HUNTER. Again, let me just make some general comments. I cannot actually, I can tell you what I participated in and our involvement in the process.

Mr. SCHEUER. Look, Dr. Hunter, make it as brief as you can. We're way over time with you. You've been a very interesting and responsive witness. Just give us briefly, how do you explain that?

Dr. HUNTER. Very briefly, the NIH has a very broad mission. They have a very large number of applications of the genome work to their very large and broad mission. They have singled it out as being of primary importance in several areas for them.

We have a mission that is related primarily in the area of radiation damage to people. And the total resources that receives in our Department is a relatively small fraction of the entire Department's budget and it does not have an enormous impact on other aspects of the Department.

So I would suggest to you, sir, that that is probably the reason for the way they look at it and the way they treat it.

Mr. SCHEUER. Okay.

If you were to get more money for your human genome research, could you use it effectively? Are you at the outer limit now of your ability to use funding in terms of your staff and time and whatnot, or could you use additional resources?

Dr. **Hunter**. Well, in the area of invention where you are trying to drive the cost of the sequencing down by a factor of 100, roughly, over what it is today, if you want to foster invention, the money by itself is an important ingredient but not the central ingredient in my opinion.

So I would say the budget we have is appropriate. We will submit it to you. Certainly if you want to try to put more money into an area, you can. I mean many people do that. The DoD, for example, often has areas where they put a lot of money in.

Mr. **Scheuer**. Well, let's not get into DoD. I mean that is such a mare's nest that all of you look good compared to DoD.

Dr. **Hunter**. What I'm saying, if you want to look at how best to develop an area, this big increase that you spoke of with the NIH actually, I believe, will be a problem for them in some sense in order to assimilate that and make sure it's spent responsibly.

What I can assure you of is the budget, as proposed to you, we will spend responsibly. We will develop new technology for you, and we will do our best to foster invention on the sequencing side. And that is not purely a matter of money. It's not even the primary ingredient.

Mr. **Scheuer**. I understand that. I understand that. There's a limit to how much resources you can shove into the funnel, into the pipeline, and still have them used cost effectively. Look, your answer was thoughtful and responsive and totally credible and we appreciate it.

One last question. The environmental problems at DOE facilities around the world, around the country, have received an inordinate amount of press attention. If you look at the 6 o'clock television news and the front page of the press, you will see DOE coming in for a real continuous, systematic, ongoing drubbing for their polluting plants.

Now, what kinds of research projects have you undertaken in the Biological and Environmental Research Program to address the long-term research needs of the Department? What kind of new technologies are you addressing? What is the funding for these new programs? And are you working cooperatively in this whole cleanup effort surrounding your plants, that whole miasma of criticism that you have run into? Are you cooperating with EPA in a joint research program? Would such a thing be feasible and, if it would, are you doing it?

Dr. **Hunter**. Sir, I would like to be able to submit an answer for the record because, particularly if you are short of time here, you've asked a complicated set of questions that are extremely important to the Department, and I would appreciate the opportunity to answer them in detail.

Mr. **Scheuer**. Absolutely.

Dr. **Hunter**. Let me just state that our programs, which include the effect of radiation, for example, on people, the joint program with Japan, roughly $17 million a year, in very long-term research on the effects of radiation, is the centerpiece of determining the effects on human subjects.

We have other work in epidemiology. We have undertaken recently an examination of our policies on the release of information. The DOE has within it for epidemiological studies probably the best set of records anywhere in the world on health effects and things of that nature.

So what we are doing right now is examining that carefully to see how best to structure it to make it available to a wide array of users and to use that information.

Mr. **Scheuer.** And you say you are carrying out joint research with the Japanese Government?

Dr. **Hunter.** Yes, sir. We have been for many years. And I will include that in the testimony, but it's to look at the effects of radiation on the survivors of Hiroshima and Nagasaki.

Mr. **Scheuer.** Well, I wish you would, because the Science Committee is visiting Japan and China this August, and I would enjoy meeting the officials over there who have been involved in this program. And if there are any glitches, let us know.

Dr. **Hunter.** Oh, I think it would be very fruitful, sir. That activity disproved a lot of theories that were held about the effects of radiation—that is, that you would get genetic mutations—it has essentially disproved that as a severe phenomenon—and represents one of the longest and best controlled samples we have of the effects. So we would be happy to give you a summary of that.

[The material referred to follows:]

COMMITTEE: SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE: NATURAL RESOURCES, AGRICULTURE
RESEARCH & ENVIRONMENT
DATE: APRIL 6, 1989
WITNESS: ROBERT O. HUNTER

INSERT FOR THE RECORD

The Biological and Environmental Research Program administered by the DOE Office of Energy Research has sponsored fundamental, long-term research related to the subsurface processes and properties that control contaminant transport since 1984.

The subsurface sciences program involves both deep microbiology research and site-directed research. The deep microbiology research program is funded at $2.7 million in FY 1989, while $3.8 million has been requested to fund this program in the FY 1990 budget request. Funding for site-directed research is $4.5 million in FY 1989, which would increase to $8.0 million under the FY 1990 budget request.

Since its inception, a goal of this research program has been to examine how complex geochemical and microbial processes interact and how mixed chemicals interact. Scientists involved in guiding this research have successfully anticipated many of the needs that are at the root of mixed waste problems, including groundwater protection, at DOE sites.

The deep microbiology research program has focused on biological and chemical remediation opportunities, such as understanding the natural biological and chemical properties of subsoils and groundwater that, in turn, might be manipulated or used to stabilize contaminants in place, to reduce the transport of contaminants, or to facilitate cleanup. Some especially innovative work has been done to define the presence and characteristics of microorganisms in deep aquifers where no practical cleanup methods now exist. Such research may lead to the identification of lower-cost cleanup technology options, exploiting natural properties and processes in place to help control contamination.

The site-directed research program is based on extensive interactions with DOE National Laboratories, operations offices, and others involved in the cleanup of contaminated sites. The research scientists involved in the site-directed program promote technology transfer by encouraging interactions among research scientists and DOE waste management staff.

In mid-March, Secretary Watkins directed the preparation of a Five-Year Plan to characterize and prioritize cleanup activities at DOE sites. One key component of the Secretary's 5-year planning initiative will be an assessment of current technology development activities that will provide the basis for future research, development, and demonstration of new and innovative technologies. Preliminary cost figures used to support the FY 1990 budget request failed to estimate the potential effect of applying new technology or innovative techniques to the cleanup effort. DOE needs to explore new ways of dealing with its waste materials, and one way to reduce environmental and health hazards is to explore the application of technologies never before considered for application to this field. This will help assure that the longer-term cleanup effort is well-focused and is based on credible science and technology.

DOE is currently establishing an environmental restoration research and development (R&D) program, with emphasis on the advancement of environmental remediation technology, to develop new technologies and management concepts to:

- minimize waste in current production, through control and chemical substitution;
- reduce the current environmental and health hazards through development of technologies in chemical extraction, bio-remediation, and, where feasible, the application of bioengineering to neutralize in-situ the toxic components of the existing contaminated sites;
- develop robotic applied technologies to reduce the potential hazard to the public, remediation technicians, and workers engaged in decontamination and decommissioning work; and,
- explore technologies not previously considered for application to this field, but used in oil and gas exploration, chemical and laser separation, radio frequency heating, and plasma cupola melting of soil.

The R&D portion of the 5-year plan will be similar to the waste cleanup portion of the Plan, although it will take longer to develop. Within DOE, direct interactions among site officials and those scientists associated with the Biological and Environmental Research Program should increase as the R&D component of the Secretary's 5-year environmental restoration and waste management plan is developed.

This new research effort will utilize unique capabilities currently available in DOE laboratories as well as in universities and industry. As new technologies are developed, promising concepts will be selected to demonstrate larger-scale applications. The National Academy of Sciences (NAS) has agreed to participate in this effort. Research funding will be reprogrammed, as necessary, and scientists currently working on these and other applicable technologies will be redirected to apply a portion of their effort toward the study of environmental and waste management applications.

There are aspects of the research conducted by DOE that can be applied to other Federal agencies involved in environmental remediation--including the Environmental Protection Agency (EPA) and the Department of Defense (DoD). The results of DOE research efforts are presently made available to other Federal agencies through such well-established mechanisms as the NAS and the Interagency Committee on Groundwater. We do not currently plan to embark on a joint research program with EPA, for example, because the focus of many EPA studies is driven by relatively short-term needs, especially in the area of the development and promulgation of regulatory standards. DOE will, however, take advantage of the work being done by EPA and by the Nuclear Regulatory Commission in development and implementation of its 5-year environmental restoration and waste management plan. This will include the coordination of the Department's efforts to complement existing and future programs in these independent regulatory agencies.

DOE's objective in undertaking this initiative is not only to establish a systematic plan in both remediation and research, but also to establish with Congress and the States agreed-upon activities that address development of new technologies, as well as our environmental cleanup responsibilities. DOE has historically been recognized around the world for its leadership in many areas, including the development of vital energy technology. Secretary Watkins believes DOE should become the world leader in the important area of environmental technology, and a valuable global resource for environmental restoration.

COMMITTEE: SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE: NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT
DATE: APRIL 6, 1989
WITNESS: ROBERT O. HUNTER

INSERT FOR THE RECORD

The Atomic Energy Commission began to fund research at the Atomic Bomb Casualty Commission in Japan in 1947 to study the effects of radiation on the atomic bomb survivors in Hiroshima and Nagasaki. In 1975, the U.S. entered into a binational agreement with the Government of Japan to continue this research. This agreement established the Radiation Effects Research Foundation and provides for equal funding from the U.S. Government and the Government of Japan.

This program addresses comprehensive research and studies on the life span, health conditions and pathological aspects of atomic bomb survivors and on any other effects of radiation on man and on diseases which may be affected by radiation. Results of this research program have provided useful information in the development of international radiation protection standards. This data forms the basis for independent organizations, such as the National Council on Radiation Protection, the International Council on Radiation Protection, and the Committee on Radiation Research and Policy Coordination, to establish radiation standards and is used in publications such as the Biological Effects of Ionizing Radiation, which is updated as new information is made available.

Mr. SCHEUER. Well, Dr. Hunter, let me thank you for your very forthcoming and frank testimony. We look forward to working with you informally on a collaborative basis to solve some of these extraordinarily important problems that you're addressing yourself to. We thank you very much for your testimony.

Dr. HUNTER. Thank you, sir.

Mr. SCHEUER. Now we will call the second panel to the witness table. Dr. David Shirley is the fourth Director in the history of the Lawrence Berkeley Laboratory. Under his direction, the Laboratory has increased its emphasis on research in the areas of basic energy sciences and the life sciences. Dr. Shirley will be retiring as Director later this year, and I would like to take this opportunity to congratulate him on the many superb accomplishments of his tenure.

Dr. Richard Setlow is the Associate Director for Life Sciences at the Brookhaven National Laboratory. He has had a long and distinguished career in nucleic acid research, and I attribute this fact and his prodigious record of accomplishment to his superb, rigorous undergraduate training at Swarthmore College, my alma mater and the alma mater of one of my top staff aides, Jacqueline Quadow Russler, sitting in the back.

Dr. Fred Morse is the Associate Director for Research at Los Alamos National Laboratory and he is accompanied by Ronald Walters, Program Director for Biological and Environmental Research.

All right, gentlemen. Why don't each of you take five or six or seven minutes to discuss informally with us your views. Your prepared statements will be printed in full in the record at this point so we don't have to be imprisoned by the paper. I hope you won't read, but you will just chat with us informally as if you are all in my living room.

Okay. Let's hear from Dr. David Shirley first. Again, congratulations on your really superb record of accomplishments.

I would congratulate Dr. Setlow because I presume he's a little bit older than you are, but Swarthmore graduates are ageless and we never retire; we just sort of fade away.

Dr. Shirley.

STATEMENT OF DR. DAVID A. SHIRLEY, DIRECTOR, LAWRENCE BERKELEY LABORATORY.

Dr. SHIRLEY. Thank you very much, Mr. Chairman, for the kind remarks. It's a pleasure to be here today to describe the involvement of the Lawrence Berkeley Laboratory in the Human Genome Project.

There are over 3,000 diseases which have significant genetic linkages. The successful mapping and sequencing of the human genome would permit precise identification of the specific disease-related genes. An immediate consequence would be a profoundly enhanced understanding of these diseases, and we can ultimately anticipate effective treatment for many of them.

In addition to the naturally-occurring genetic diseases, there is also a complex interaction between the environment and our genetic heritage. Advanced technologies impose effects on the environment which may intensify or reduce that interaction.

The Department of Energy and its predecessor agencies, the Atomic Energy Commission and the Energy Research and Development Administration, have long been involved in research to understand and to mitigate the biological effects of these technologies.

I would remind you that in March 1986, the Department of Energy convened an International Science Workshop which concluded that the genome project was a worthy goal that could be successfully completed. DOE then requested the advice of its Health and Environmental Research Advisory Committee, or HERAC, which strongly encouraged DOE to support this major new initiative.

Support for the project has also come from reports by the National Research Council and the Office of Technology Assessment. All of these reports recognize the unique capabilities of DOE's National Laboratories. These labs are based on the multidisciplinary team concept pioneered by the Lawrence Berkeley Laboratory's founder, Ernest Lawrence.

For the Human Genome Project, biologists, chemists, engineers, computer scientists, and physicists must be marshalled to develop the advanced sequencing instrumentation and computer data base technology essential to the project's success.

My enthusiasm for DOE's critical role should not be seen as a lack of support for the different role of the National Institutes of Health. NIH traditionally supports single investigator projects which will also be important in being brought to bear on the Human Genome Project. In particular, NIH is the only agency looking at non-human genomes. And NIH-funded researchers will be the main resource for examining connections between the genome data and how our bodies function.

On the other hand, DOE's expertise is in multidisciplinary technology which is essential to ensure expeditious progress on the genome project.

Since the founding of our laboratory on the University of California, Berkeley campus in 1931, the biological sciences have been an important part of its research mission. Recent achievements, include the development of the world's highest resolution Positron Emission Tomography scanner, the PET scanner, along with continuing successful research into the uses of heavy ions in the treatment of cancerous tumors.

Biophysics and biochemistry research at LBL includes the examination of radiation and its effect on the damage and repair mechanisms in human DNA.

Other laboratory work in cellular, molecular and structural biology provides a unique opportunity for DOE to use the strong collaboration between LBL and the University of California campuses to benefit the genome project.

LBL was chosen as one of two DOE Human Genome Centers on September 9, 1987. A national search for the Center Director culminated in the selection of Dr. Charles Cantor. Dr. Cantor is a member of the National Academy of Sciences. He's an internationally recognized expert on genetic mapping and sequencing and most recently has been professor and chairman of the Genetics and

Development Department at Columbia University. His major contribution to the field has been the development of a technique to separate fragments of DNA.

Dr. Cantor's leadership, combined with the existing expertise at the Laboratory and at UC-Berkeley will provide LBL's Human Genome Center with capabilities unexcelled in any single location. Much of the work so far has focused on renovating individual laboratories and on obtaining and developing the equipment necessary for the long-term goals of the project.

LBL scientists and technicians have already made significant advances. We have designed a pulsed field gel electrophoresis test bed that will for the first time allow researchers to monitor physical conditions in the gel. This ability will provide an understanding of how large fragments of human DNA migrate and separate. We have also devised a semi-automated method that analyzes images of DNA separations, determines the fragment length and other properties, and automatically enters this information into a genetic data bank.

I have major concern for the future of LBL's Human Genome Center, and that is the lack of adequate modern laboratory space. We have already resorted to borrowing space from other important projects and placing people and equipment in space barely adequate for even the short term.

The Laboratory does not have empty or underutilized space available for the project. A new laboratory building is essential. The Laboratory proposed to DOE the construction of an $11.6 million Human Genome Laboratory beginning in fiscal 1990. We understand that DOE included this proposal in its submission to OMB, as you indicated earlier, but it was not included in the administration's fiscal 1990 budget request.

It is critically important to the success of our Human Genome Center that we acquire the necessary laboratory space. The committee's recognition of this need could strengthen the administration's support in the future.

In closing, I would like to emphasize again the central role that the Department of Energy National Laboratories will play in the Human Genome Project. And I would like to voice a final concern. The proposed increase in DOE's genome budget from $17.5 million in fiscal 1989 to $27.5 million in 1990 is only just adequate to move aggressively forward with the project, especially by comparison to the huge increase proposed in the NIH genome budget from $27 million in fiscal '89 to $100 million in 1990.

Mr. SCHEUER. Well, let's liberate ourselves from the printed page for a moment, okay? I tried to elicit some views from Dr. Hunter about what looked to me to be a very disproportionate allocation of funding.

Just speaking informally, representing no one but yourself, if you take the total increase which is about $110 million, $73 million for NIH and $10 million for DOE, so that's about $85 million, $84 million—if you say that we're going to put another $84 or $85 million into human genome research and you are a scientist from Mars, a very, very clever fellow who really wanted to spend this money cost effectively, with the maximum utilization of human resources, would this visitor from Mars who is head of their Genome

Research Project, perhaps wanting to cooperate with us and wanting to make sure that we were using talent and funds effectively, would that person go back to his government and say, "They're doing wonderfully. They're giving $10 million more to DOE and $73 million more to NIH"? Or, would he say, "That's a disproportionate allocation of funds. They're not maximizing with that additional $84 million the potential for those two agencies whose missions are really quite complementary and have an obvious interface, they're not really allocating those funds optimally to achieve the greatest total result from the collaborative work of the two agencies"?

What would you go back and tell your government in Mars?

Dr. SHIRLEY. Well, speaking as a scientist from Mars, I think I would say that I did not understand this pair of increases. It would appear to me that either there was a lack of coordination or that there had been a conscious decision to shift the emphasis from the DOE to the NIH.

Dr. Hunter has assured us that that was not the case. There is, of course, the issue of the perception that the public and that the scientific community will have on seeing these numbers, and the perception that naturally occurs to one is that there has been a shift in emphasis or possibly even a transfer of the center of gravity of the program.

Mr. SCHEUER. Well, there might very well be a justification. I can think of a theoretical justification for the transfer of the center of gravity. If from the point of view of the quality of the staff, the quality of the administrative capability, it seemed that it would be far better managed at NIH, then so be it.

We have absolutely no vested interest in either NIH or the DOE. What we have a vested interest in at a time of real resource constraints is making sure that each dollar we spend literally squeals for mercy and that we get maximum effectiveness and maximum productivity from each dollar expended. And that means we have to fine-tune the expenditure of funds on a joint program between NIH and DOE and make sure that these dollars are optimally spent to take advantage of the talent and the resources in each of these agencies.

One wonders when one agency gets $10 million and another gets $84 or $85 million, what are the reasons for this discrepancy. Could it be that DOE has a mission to do one cut of the total genome research project and that NIH has the rest of the pie? In other words, DOE has a major slice but NIH has the rest of the pie, and that if the rest of the pie is eight or ten times the order of magnitude of the slice of the pie that's been assigned to DOE, then that might be a logical transfer of resources to enable DOE to fill its mission with the larger portion of the pie.

Could that be an explanation? Is there any other explanation that escapes my notice?

Dr. SHIRLEY. Mr. Chairman, as a Director of a National Laboratory, I have experience, of course, with managing programs in several areas of research. Among the programs that are particularly well planned and coordinated are those in the area of high energy physics.

I would make an analogy in this case with a project in which you were going to, for example, build an accelerator that involved new technology that was right on the frontier of knowledge. Before building the accelerator, you would do a lot of R&D until you decided how you were going to build it, and then you would see the transfer of funds, you would see a movement of funds into the actual project itself.

In the DOE, we regard the genome centers and the DOE program as being the project per se. So we believe that when the R&D is done, the supporting R&D is done, it is explicitly addressed to the technology of how you map and sequence the human genome. We would then expect the project to grow by leaps and bounds and to be carried through systematically to a conclusion.

The only analogy that I can reasonably make between the NIH program and the DOE program is that the NIH program is analogous to the supporting R&D.

[The prepared statement of Dr. David A. Shirley follows.]

Written Testimony of David A. Shirley
Director, Lawrence Berkeley Laboratory
House Science, Space and Technology Committee
Subcommittee on Natural Resources, Agriculture Research and Environment
April 6, 1989

Mr. Chairman and Members of the Subcommittee, it is a pleasure to be here today to describe for the Committee the involvement of the Lawrence Berkeley Laboratory in the Human Genome Project. I shall provide some background as to the development of the project, describe the critical role of the Department of Energy since its inception, and then outline for you Lawrence Berkeley Laboratory's mission as one of two DOE Human Genome Centers.

The Los Angeles Times has speculated that the Human Genome Project "may be one of the most important scientific activities of this century." I agree with this assessment, because securing the complete genetic "Book of Man" is certainly a heroic endeavor. As Federal support for the project as grown, so has the scientific conviction that the mapping and sequencing of the human genome is not only possible but inevitable.

Over 3,000 diseases have significant genetic linkages. The successful mapping and sequencing of the human genome would permit precise identification of specific disease-related genes. An immediate consequence will be a profoundly enhanced understanding of these diseases, and we can ultimately anticipate effective treatments for many of them. The knowledge we gain may well mean the end of such costly and debilitating diseases as Alzheimer's, sickle cell anemia, and certain forms of heart disease.

In addition to naturally occurring genetic disease, modern society has learned that there is a complex interaction between the environment and our genetic heritage. As we develop advanced technologies, we impose effects on the environment which may intensify or reduce that interaction. The Department of Energy is responsible for the development of improved technologies for energy production, conversion, and utilization. In order to understand and mitigate the biological effects of these technologies, the Department and its predecessor agencies, the AEC and ERDA, have long been involved in genetics research. The AEC actually provided the first major Federal support in this area. Since that time, DOE has been deeply involved in research on DNA damage and repair, the development of medical imaging technologies, the use of radiation for treatment of cancer and the examination of the chemical and genetic bases of photosynthesis. This history of genetics research first led DOE to examine the possibilities inherent in the Human Genome Project. In March 1986, Charles De Lisi, then Associate Director for Health and Environmental Research in DOE, convened an international scientific workshop at Santa Fe, New Mexico.

The workshop participants concluded with virtual unanimity not only that the genome project was a worthy goal but that its successful completion was possible. This support led the Department to call upon its Health and Environmental Research Advisory Committee (HERAC) to examine further the feasibility of the project and the role of the Department of Energy. In its report, issued in April 1987, HERAC strongly recommended that the DOE fund a "major new initiative whose goal is to provide the methods and tools which will lead to an understanding of the human genome." The report also encouraged wide collaboration with other Federal agencies and with other nations, but specifically recognized the unique role that DOE could play in the project. Since that time, support for the initiative has come from a February 1988 National Research Council report and an April 1988 report by the Office of Technology Assessment.

All of these reports have recognized the unique capabilities that DOE and its National Laboratories can bring to bear on the Human Genome Project. DOE's laboratories are based on the multidisciplinary team concept pioneered by Lawrence Berkeley Laboratory's founder, Ernest O. Lawrence, who realized that complex scientific projects required the coordinated efforts of scientists and engineers. The development of particle accelerators, high resolution Magnetic Resonance Imaging technology, and advances in supercomputer technology, to name a few, have relied on the unique environment of DOE's national laboratories. For the Human Genome Project to succeed, this coordination of many capabilities within the context of a broad unified scientific vision will be crucial in providing the long-term team effort required. The wisdom and talents of biologists, chemists, engineers, computer scientists, and physicists must all be marshalled to develop the advanced sequencing instrumentation and computer database technology essential to the project's success.

My strong enthusiasm for DOE 's critical role in the Human Genome Project should not be seen as a lack of support for the different role that the National Institutes of Health (NIH) can play. LBL has been extremely successful in competing for NIH grants, whose research complements that of DOE. LBL today receives over $13 million a year in NIH grants, which expressed as a percentage of the operating budget is higher than any other DOE national laboratory. NIH in its traditional support for single investigator projects supports outstanding scientific research which must be brought to bear on the Human Genome Project. In particular, the NIH is the only agency that will be looking at non-human genomes, and NIH-funded researchers will be the main resource for making meaningful connections between the genome data and how our bodies function. On the other hand, multidisciplinary technology development is more naturally the province of the Department of Energy, and without new tools, expeditious progress on the genome project is impossible.

LBL is very proud to have been given a leading role in this exciting adventure. Since the founding of this Laboratory on the University of California, Berkeley campus in 1931, the biological sciences have been an important part of LBL's research mission. When John Lawrence, a Yale physician, joined his brother in 1937 to study the first medical applications of cyclotron particle beams, the field of nuclear medicine was born. Over fifty years later, LBL is still the home of pioneering research in nuclear medicine. Recent achievements include the development of the highest resolution Positron Emission Tomography scanner in the world, along with continuing successful research into the uses of heavy ions in the treatment of cancerous tumors.

Biophysics and biochemistry research at LBL includes the examination of radiation and its effect on the human DNA damage and repair mechanisms. Other Laboratory work in cellular, molecular and structural biology provides a unique opportunity for DOE to use the strong collaboration between LBL and the University of California campuses to benefit the genome project.

Because of these strengths in technology development and biological research, LBL was chosen as one of two DOE Human Genome Centers by Secretary Herrington on September 9, 1987. Since that time, we have moved forward aggressively to organize the Center. A national search for the Center Director culminated in the selection of Dr. Charles Cantor as the Director of LBL's Human Genome Center. Dr. Cantor, a member of the National Academy of Sciences, is an internationally recognized expert in genetic mapping and sequencing who most recently has been Professor and Chairman of Genetics and Development at Columbia University. His major contribution to the field has been the development of a technique known as pulsed-field gel electrophoresis to separate fragments of DNA. Dr. Cantor's leadership, combined with the existing expertise at the Laboratory and the University of California, Berkeley, will provide LBL's Human Genome Center with capabilities unmatched in any single location.

Since the genome project relies on the cooperative as well as coordinated efforts of an international community, LBL's Center needs insight and critique from the leaders of this field. Late last year, I announced the appointment of LBL's Human Genome Center Advisory Committee. The quality of an advisory committee often reflects the organization it is advising, and I am very proud of the caliber of people who have accepted the challenge of guiding our Center. The list includes Professor Bruce Alberts from the University of California at San Francisco, Chairman of the National Research Council genome report; Sir Walter Bodmer,Director of Research for the Imperial Cancer Research Fund in England; Dr. David Botstein, Vice President for Research at Genentech Inc.; Dr. Charles DeLisi, the "founding father" of the DOE human genome project; Nobel Laureates Renato Dulbecco of the Salk Institute and Walter Gilbert of Harvard; Dr. Maxine Singer, President of the Carnegie Institute of Washington, D.C.;.and Dr. Nancy

Wexler, President of the Hereditary Disease Foundation. The committee held its first meeting on March 21 and strongly affirmed the research strategy of the Center. This stellar panel will be of invaluable help to the Center's scientific activities.

Much of the work of the last year has focused on renovating individual laboratories and on obtaining, and often developing, the equipment necessary for the long-term goals of the genome project. LBL's genome center has a number of components that will integrate the genome research of other DOE and NIH efforts. Our technology development program will emphasize development of new approaches to mapping and sequencing and on streamlining them through automation. We will finish genetic maps left uncompleted by others, develop methods to assemble data acquired by others, and resolve discrepancies efficiently. Once genetic information is available from our mapping and sequencing processes, we will establish a structure-based sequence analysis program and develop a high-resolution system for examining DNA mutations.

Already LBL scientists and technicians have made significant advances. We have designed a pulsed-field gel electrophoresis test bed that will, for the first time, allow researchers to monitor physical conditions in the gel. By understanding how large fragments of human DNA migrate and separate, we will be able to control the process and optimize separations of molecules of specific length and size. We have developed techniques for micromanipulating and visualizing small DNA molecules for further genetic analysis. We have also devised a semiautomated method that analyzes images of DNA separations, determines the fragment length and other properties, and automatically enters this information into a genetic data bank.

I have two major concerns for the future of LBL's Human Genome Center. First is the lack of adequate modern laboratory space. Our current plans for the Center show a staff increase from 25 in FY 1989 to 68 by FY 1992, yet our current staff is working under difficult conditions. We have resorted to borrowing space from other important projects, to their long-term detriment, and to placing people and equipment in space that can only be described as barely adequate for the short term. The Lawrence Berkeley

Laboratory does not have empty or underutilized space available for the project; a new laboratory building is desperately needed. The Laboratory proposed to DOE the construction of a Human Genome Laboratory beginning in FY 1990. The proposed four story, $11.6 million laboratory would provide 20,000 assignable square feet for mapping and sequencing laboratories, data processing facilities, biochemistry bench space, cell and tissue culture laboratories. We understand that DOE did include a request for the Laboratory in its submission to OMB, but it was not included in the Administration's FY 1990 request. It is critically important to the success of our Human Genome Center that we acquire the necessary laboratory space. The Committee's recognition of this need could strengthen the Administration's support in the future.

In closing, I would like to emphasize again the central role that the Department of Energy, and its national laboratories, will play in the Human Genome Project, and to voice my second concern. The increase in DOE's genome budget from $17.5 million in FY 1989 to $27.5 million is only just adequate to move aggressively forward with the project, especially by comparison to the very much larger increase in the NIH genome budget from $27 million in FY 1989 to $100 million in FY 1990. I believe that the Congress should reaffirm to the Administration the important role of DOE in this project, and strongly support both increases in the operating budget for DOE's effort as well as the construction of desperately needed new laboratory space. I appreciate the opportunity to testify today and I will be happy to answer any questions.

Mr. **Scheuer**. All right, Dr. Shirley, I very much appreciate your testimony. It has been extremely helpful. I've gone way over what the time should have been.

I have two very distinguished colleagues here who joined us, the Ranking Minority Member of this subcommittee, Claudine Schneider of Rhode Island, and David Skaggs of Colorado, a very contributing new member of the committee. All right. We will go on now to Dr. Setlow. Going off the record.

[Discussion off the record.]

Mr. **Scheuer**. Back on the record.

Dr. Dick Setlow, we are delighted to welcome you here. Please take the same five, six, or seven minutes and try to liberate yourself from the printed page if you can, and just chat with us.

STATEMENT OF DR. RICHARD SETLOW, ASSOCIATE DIRECTOR FOR LIFE SCIENCES, BROOKHAVEN NATIONAL LABORATORY.

Dr. **Setlow**. I am going to chat with you, and I have liberated myself from the printed page. But what I shall try to do is to show you some pictures so that you really get a feel for what the Department of Energy is doing in the medical application to nuclear—

Mr. **Scheuer**. Why don't you come around here?

Dr. **Setlow**. I have to operate the machine. I'm doing two jobs today.

Mr. **Scheuer**. We're going to get somebody else to operate the machine for you.

Going off the record again...

[Discussion off the record.]

Mr. **Scheuer**. Back on the record.

Dr. **Setlow**. I want to tell you about three advances in nuclear medicine that are ongoing.

Mr. **Scheuer**. Dick, I want you to come back and stand here. We are going to take some pictures.

[Photos taken.]

Mr. **Scheuer**. Back on the record.

Dr. **Setlow**. I appreciate the effort to get my picture into the Swarthmore Phoenix.

I am going to speak about three aspects of nuclear medicine or medical applications of nuclear technology that are advancing very rapidly and, it goes without saying, need a bit more support. I shall not really address that. I want to give you a feel for what is happening.

[Slide.]

Dr. **Setlow**. One is something that Dr. Shirley mentioned, and that is so-called PET studies, Positron Emission Tomography, a technique that permits one to localize short-lived isotopes such as Carbon-11, 20 minutes half-life, in particular locations in the brain. It is useful to study disease and, in this case, to do something about the molecular and cellular biology of cocaine.

So here is a molecule, Carbon-11-labeled cocaine. It has a short half-life. It has to be made in a cyclotron, synthesized into cocaine, put into subject, and analyzed in a rather elaborate detector computer system.

[Slide.]

Dr. SETLOW. The next slide shows you what the computer turns out. These are simulated slices through human brain, top left to the bottom right being top to the bottom of the brain, and the bright spots show where the cocaine is located. And you can see they're located in a particular position at about 15 minutes after injection.

[Slide.]

Dr. SETLOW. And the next slide shows what happens at different times after injection. You can see that this maximum intensity in the middle of this slice is somewhere in the neighborhood of five to ten minutes. And the intriguing thing about this five to ten-minute time is that this is the time that an individual who injects cocaine feels the high. So the kinetics of the process are the same.

Mr. SCHEUER. Cocaine is ordinarily ingested by snorting through the nasal passages. How would this affect the speed of—

Dr. SETLOW. This actually is crack. And that would be injected. It's a derivative of cocaine.

Mr. SCHEUER. No, but cocaine for centuries, many many generations—

Dr. SETLOW. I'm not an authority on this. Swarthmore didn't teach me that. It would take a longer time. It would have to go through the nasal mucosa and then into the body, and there would be a longer time. This is actually done in another way. So this is a way really of getting at it.

Mr. SCHEUER. But the other pharmacological effects would be the same.

Dr. SETLOW. Yes. This is just faster. The point is that the kinetics, the pharmacokinetics from what you see in these pictures are the same as the psychological picture. So that is one aspect.

I want to turn now to another nuclear medicine, one, that again, Dr. Shirley mentioned.

[Slide.]

Dr. SETLOW. And this has to do with using synchrotron radiation in what is called x-ray angiography. The idea is to try to detect something about the status of heart arteries. Normally, when you take an x-ray picture with a low contrast agent, as in Part A, it is very difficult to see the artery because there is poor contrast. You can get better contrast by putting in more contrast agent, but that is dangerous and has its hazard to the individual; or you can use tricks to reduce the background. And that is what one of these tremendous instruments called a synchrotron light source does.

[Slide.]

Dr. SETLOW. What I'm going to show you is the preliminary work done at the Stanford Synchrotron Research Laboratory. Their synchrotron is adequate to show this mock-up of a human heart, which is really a pig heart, and superimposed on it is a human skeleton, a vertebra. Now, you can't see very much in this because I haven't reduced the background. This is what we're trying to look at—poor contrast.

[Slide.]

Dr. SETLOW. And the next slide shows the background. It almost looks the same. You can't see it. But by the tricks done with the synchrotron radiation that I can't tell you all about, you get the next picture.

[Slide.]

Dr. SETLOW. Almost by magic, you can subtract out the background and see the actual arteries. Now, these are large machines. The instrumentation from Stanford is being moved to Brookhaven because Brookhaven's synchrotron has more intensity and so it can look at a thicker object like a human heart, and this is one of the biological indications of why we want advanced light sources. You really can do good medical applications.

[Slide.]

Dr. SETLOW. The last one, if I could have the next slide, is a scheme called Boron Neutron Capture Therapy, and this is a cartoon designed to show about how it works. Suppose there is a tumor in the brain and you could figure out a way of getting boron on some sort of a carrier or vehicle into that tumor.

One then irradiates the tumor with neutrons, slow neutrons. The slow neutrons are absorbed by a particular isotope of boron, Boron-10, and they destroy the boron nucleus. It gives rise to ionizing particles that kill the cell.

To make this an effective therapy requires knowledge of two dosimetries. One I have called neutron dosimetry and the other boron dosimetry. And the boron dosimetry is hard to do because you have to get a drug that will latch onto the boron and carry it to the place that you want, not the overriding tissue. So there is a lot of research to be done before this could be done in people. You have to know the pharmacokinetics and dynamics, and I just wanted to show you two examples from work at Brookhaven that really show great promise, at least in animals. And so we want to go from animals to people.

[Slide.]

Dr. SETLOW. The next slide shows one of these. This is an attempted cure of melanomas in mice, using neutrons. And the carrier here I have called BPA. It's an analog of an amino acid, phenylalanine, that's metabolized and goes into melanin, the pigment in melanoma. So it's a natural carrier.

And if you put neutrons plus BPA into a mouse, the lower curve shows that the tumor does not grow, whereas if you didn't do anything the tumor grows rapidly and the animals die in just a few days.

[Slide.]

Dr. SETLOW. The last slide is one showing another kind of boron carrier that can go into the brain, in a brain tumor, a glioma. This happens to be gliomas in rats. You can see if there is no irradiation, these animals die—in the left-hand scale—in about nine days. It is a very aggressive tumor. If you treat them with boron plus neutrons, the life span is about 46 days and some animals actually survive. So there is a factor of five or so improvement in the therapeutic outcome.

So that is really the three examples I wanted to give of the forefront research in nuclear medicine. The only general comment I would have to make about funding applies not only to medical applications, but applications such as structural biology and I'm sure also genome, and that is that the biological budget in DOE for equipment—remember, you need not only brains and people, but you need equipment—the equipment budget for the past seven years has been of the order of 5 percent of the operating budget. It is not possible to do forefront research with that. It must be at least 10 percent.

Mr. SCHEUER. Is there a rule of thumb as to the relationship that the equipment budget should bear to the operating budget?

Dr. SETLOW. Of the order of 10 percent—or more in some fields. At least 10 percent. The Department of Energy has fallen behind for seven years at least in that, and so there's an accumulation of requests for state of the art equipment.

With that, Mr. Chairman, I will end my remarks.

[The prepared statement of Dr. Richard Setlow follows.]

Testimony of

Richard B. Setlow

before the United States House of Representatives

Subcommittee on Natural Resources, Agriculture Research

and Environment

of the

Committee on Science, Space, and Technology

6 April 1989

Research Into Medical Applications of Nuclear Technology at the Brookhaven National Laboratory

Richard B. Setlow[*]

Research in the Life Sciences at Brookhaven is carried out in four interacting departments—the Department of Applied Science (the global environment), the Biology Department (molecular biology, genome research, and structural biology using the Laboratory's unique user-oriented facilities), the Chemistry Department (a regional Positron Emission Tomography (PET) Center), and the Medical Department (cytogenetics, radiation biology, and various aspects of nuclear techniques applied to problems of human health). In the human health area at Brookhaven, there is state-of-the-art research on the production of radioisotopes, the use of such isotopes to label specific monoclonal antibodies that may be of use for diagnosis and therapy, body scans to localize isotopes that emit single photons, PET scanning to estimate metabolic events and receptor sites in the brains of normal and impaired humans, noninvasive coronary angiography at the National Synchrotron Light Source in collaboration with investigators at the Stanford Synchrotron Radiation Laboratory (SSRL), and boron neutron capture therapy. Time does not permit an adequate description of all these various endeavors. I shall concentrate on the last three because they are in a state of rapid growth and have the potential for explosive advances in diagnosis and therapy of human disease.

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[*] I am a Senior Biophysicist and the Associate Director for Life Sciences at the Brookhaven National Laboratory. I received my A.B. in Physics from Swarthmore College in 1941 and my Ph.D. in Physics from Yale University in 1947. I was on the staff of the Physics and Biophysics Departments at the University from 1943 to 1960. From 1961 to 1974 I was on the staff of the Biology Division of the Oak Ridge National Laboratory and on the faculty of the University of Tennessee. At Oak Ridge, I was the Scientific Director of Biophysics and Cell Physiology and at the University, was for two years the Director of the University of Tennessee Oak Ridge Graduate School of Biomedical Sciences. In 1974 I came to Brookhaven as a Senior Biophysicist. In January 1989 I received an Enrico Fermi Award from the Department of Energy for "pioneering and far reaching contributions to the fields of radiation biophysics and molecular biology, beginning with the discovery and conceptualization of the processes of DNA repair that have had an impact on research in genetics, recombination, mutation, and carcinogenesis." A further description of the award is given in the Congressional Record, Vol. 135, p. S933, (1989). A brief curriculum vitae is given in Appendix I.

Positron Emission Tomography. If a radioisotope emits a positive electron, a positron, the positron is annihilated before it goes an appreciable distance in tissue and gives rise to two gamma rays traveling in opposite directions. Measurements of large numbers of annihilation events permits one to determine where the positron emitters were localized in, for example, brain. Obviously, there is a lot of ingenious instrumentation involved in this determination. A crucial part of PET is the rapid synthesis of biological molecules containing positron emitters. An example from the work of Wolf, Fowler, and Volkow of Brookhaven on [^{11}C] cocaine is shown in the following three Figures.

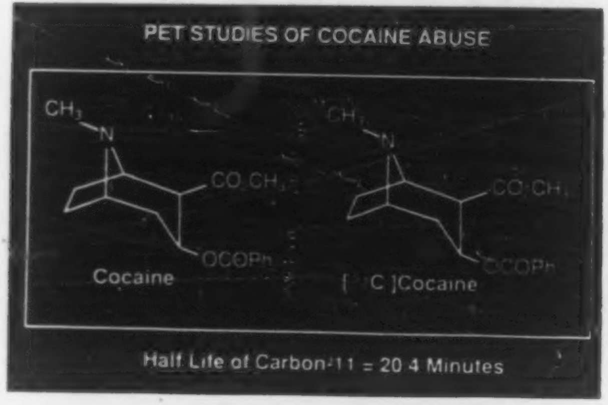

PET STUDIES OF COCAINE ABUSE
CH3
N
CO2CH3
OCOPh
Cocaine
CH3
N
CO2CH3
OCOPh
[11C]Cocaine
Half Life of Carbon-11 = 20.4 Minutes

Figure 1: The structure of ^{11}C-labeled cocaine.

Because of the short half life of ^{11}C, it is necessary that the production of the radioisotope be closely coupled to an organic synthesis laboratory and a medical facility and PET scanner for human studies. PET scans obtained at Brookhaven using ^{11}C-labeled cocaine are shown in Figure 2.

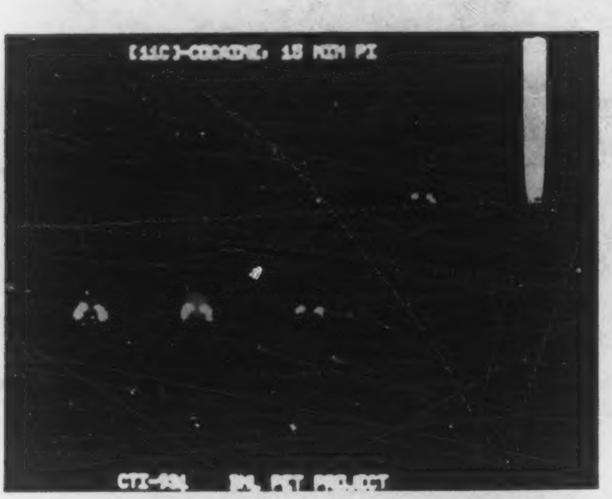


Figure 2: [^{11}C] cocaine binding in human brain at 15 minutes after injection as measured by PET. Brain slices from the top of the head to the base of the skull are shown from the upper left to the lower right. Slices 7 to 11 localize the positions of maximum concentration.

Not only can one localize cocaine binding sites in the brain, but it is possible to measure the rate at which the cocaine becomes bound after injection. A typical scan at the region of maximum binding is shown in Figure 3 for different time intervals after injection.

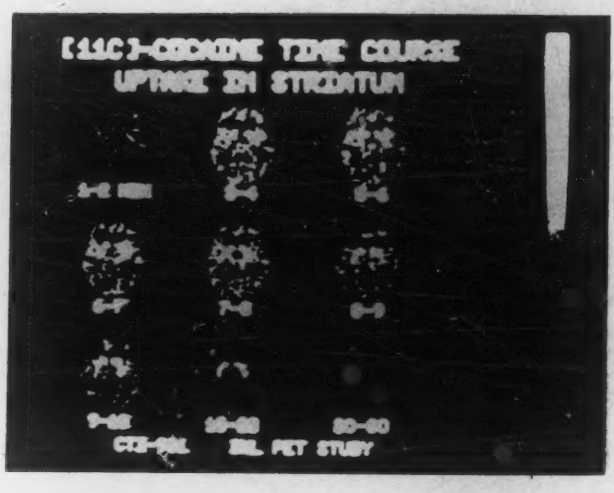


Figure 3: The time course of [^{11}C] cocaine binding in human brain at the level of the striatum showing that peak uptake is in the range of 4 to 10 min.

It is intriguing that the time at which maximum binding occurs also seems to be the time at which cocaine produces a subjective "high", suggesting that the behavioral elevation after cocaine is injected is associated with its binding in the striatum.

Noninvasive Coronary Angiography. It is important to obtain good images of coronary arteries for diagnostic purposes and as guides to possible surgery. However, x-ray images of the heart cannot reveal these arteries because of the lack of contrast between them and the rest of the surrounding tissue. Even the injection of small amounts of contrast agent are insufficient to reveal the arteries (Figure 4a).

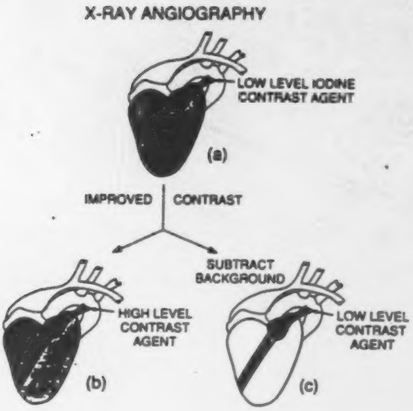


Figure 4: A cartoon showing two ways of increasing contrast in x-ray angiography. Part (c) would utilize the radiation from a synchrotron light source.

The principal approach to circumventing the low contrast is to inject, close to the heart, a large amount of a contrast agent (Figure 4b). This procedure is laborious and carries some risk. A better approach would be to decrease the background x-ray absorption (Figure 4c) so as to permit the use of low amounts of contrast agent with attendant low risks. Researchers at SSRL have devised a technique to do just this, making use of the very high intensity x-rays available from synchrotron light sources (the Brookhaven Synchrotron beam is much more intense than the Stanford one and available for much longer periods of time permitting careful evaluation of the technique in numerous human subjects). The way in which the subtraction of background is carried out is illustrated schematically in Figure 5.

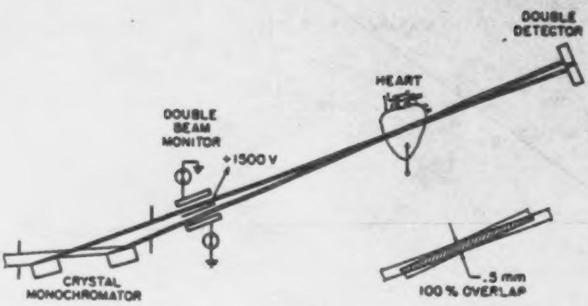
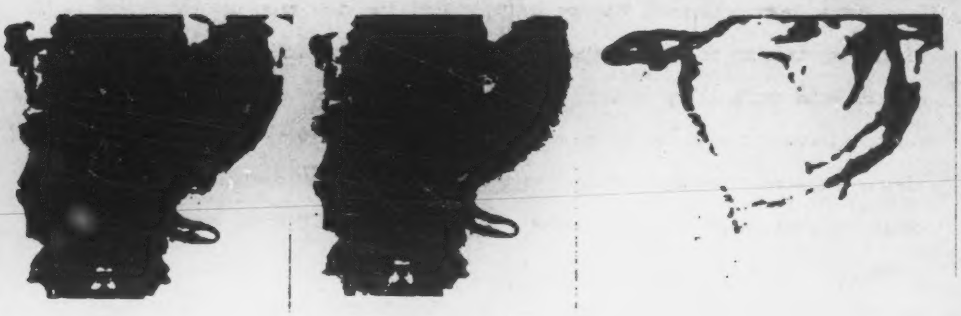


Figure 5: A schematic diagram of imaging a section of the heart by two x-ray beams.

X-rays containing many wavelengths emitted from the Synchrotron ring fall on two monochromators that are adjusted to give wavelengths absorbed either strongly by iodine or by the background tissue. These two beams pass through the same region of the heart and fall on two detectors whose output goes into a computer that performs the subtraction of the background absorption. In order to image the entire heart the patient is moved through the beam so that a number of 4 msec slices are taken of the heart in a time between 1 and 2 sec. Figure 6 shows images obtained at SSRL on an analog of a human heart—a pig heart plus a human spine.



(a) (b) (c)

Figure 6: Absorptions by an analog of a human heart: (a) at an x-ray wavelength strongly absorbed by the contrast agent, (b) at a wavelength not strongly absorbed by the contrast agent, and (c) the difference between a and b.

It is obvious from Figure 6 that the subtraction of background may be accomplished effectively and permits—almost like magic—the visualization of coronary arteries. Moving the equipment from SSRL to Brookhaven, setting it up, and beginning the initial patient trials will take approximately 9 months. Obviously, there are many improvements that can and should be made in this system. Hence, there is a need for more fundamental research on the imaging process and how better to do it, as well as on the medical results of such imaging.

A recent description of the technique will be found in the Journal of the American Medical Association (March 10, 1989, Vol. 261, page 1387).

Boron Neutron Capture Therapy (BNCT). Ionizing radiation is used extensively in attempts to control the growth of tumors. The efficacy of the therapy depends upon the ability to localize the dose in the tumor while sparing the normal tissue and upon the sometimes greater radiosensitivity of the tumor tissue compared to normal tissue. If a tumor is not well localized or if its cells are radioresistant, the therapy may be ineffective. Boron neutron capture therapy attempts to increase selectively the radiation dose to tumor tissue by the use of a sensitizer, ^{10}B, preferentially localized in tumor cells. The irradiation of ^{10}B by slow neutrons results in neutron capture and the splitting of the boron nucleus into an alpha particle and a lithium nucleus. These two fragments recoil from one another and produce dense local tracks of ionization confined to cellular dimensions that readily kill cells. Figure 7 is a cartoon illustrating the process as applied to brain tumors—tumors often very difficult to control. The general idea is to design drugs, that will preferentially localize in tumors, to which ^{10}B may be linked covalently. Upon irradiation of the tumor-containing tissue with slow neutrons, ionizations are deposited selectively within tumor cells. In such a therapy there are two doses to be concerned with. The first is the neutron dosimetry—a subject that is handled relatively easily by reactor engineers and health physicists. The second and more difficult problem is to design the boron-containing drugs and to ensure their uniform distribution among the tumor cells with a low concentration in the surrounding non tumor tissue. Hence, one can appreciate that different drugs may be required for different tumor types and that the route and time of administration and irradiation may depend on the tumor type. Thus, the biological problems are not simple ones, but will require a large amount of background basic research using animal models before clinical trials can be started. A number of Laboratories throughout the United States are collaborating in these endeavors. At Brookhaven we have a relatively small research reactor—the 5 MW Medical Research Reactor specifically designed for biomedical research—as an appropriate source of slow neutrons. There have been two recent success stories for BNCT using this Reactor to attempt a cure of transplanted tumors in animals.

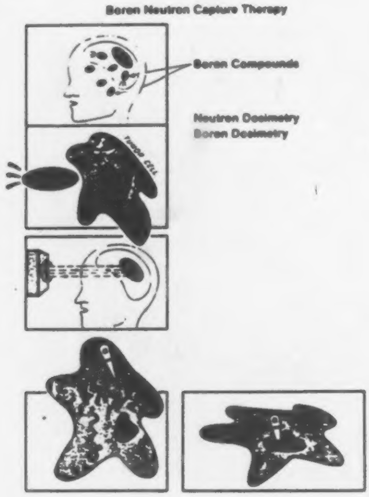


Figure 7: A cartoon illustrating BNCT and the need to know both neutron and boron dosimetries.

The first success is the use of an analog of the natural amino acid phenylalanine, borono-phenylalanine (BPA). Melanomas metabolize such amino acids and use the metabolic products as precursors for the synthesis of the pigment melanin. Hence, this boron carrier selectively concentrates boron in melanoma tissue. The model system that has been used[1] is a mouse melanoma implanted below the skin of the thigh of recipient animals. Figure 8 shows the growth of this tumor in unirradiated animals, in animals whose thighs were irradiated only with neutrons, and in animals given the combined therapy of borono-phenylalanine and neutrons. It is clear than BNCT is effective in controlling tumor growth. Eleven out of 19 (60%) animals survived whereas the untreated animals all died and animals treated with neutrons alone only showed a survival of 4 out of 22 (20%). Borono-phenylalanine has recently received an investigational new drug approval for phase I studies of human malignant melanoma.

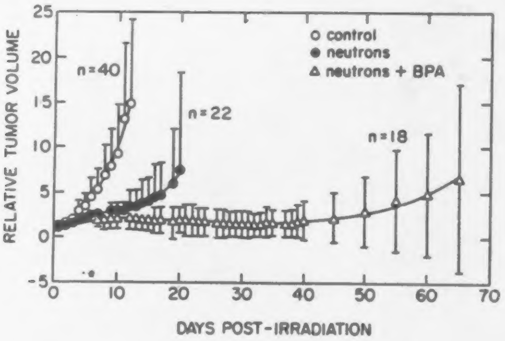


Figure 8: The results for irradiations of thigh tumors in mice at 14 days after implantation. The points represent the average tumor volume for all the animals in the mode of treatment indicated. Unirradiated animals did not survive beyond 15 days. The long term survivors after neutrons alone amounted to 20% and the survivors after neutrons plus borono-phenylalanine were 60%.

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[1] J. A. Coderre et al. Boron neutron capture therapy of a murine melanoma. Cancer Research 48, 6313 (1988).

The second effective therapy was for an intracerebral transplanted rat glioma. In this case the boron carrier was a sulfhydryl borane dimer that was infused into the peritoneal cavity for 72 hrs before irradiation at the Reactor. Irradiation was given 14 days after the initiation of the tumors because at this time the tumor volume was approximately one-third of the volume that would kill the animal. This volume was chosen for irradiation because human cerebral gliomas typically result in initial symptoms when they are approximately one-third of the size that causes death. Figure 9 from the work of D. D. Joel and collaborators at Brookhaven shows the impressive results that can be obtained by proper attention to drug delivery and dosimetry. BNCT increases the median survival time by 5-fold.

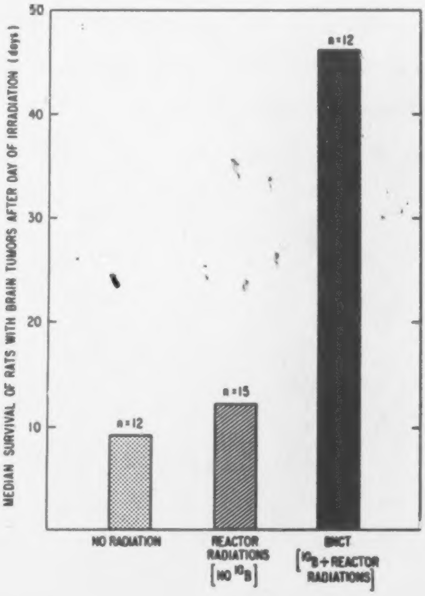

Figure 9: The median survival time of rats containing transplanted gliomas after various treatments given 14 days after transplantation. The average ^{10}B concentration was 30 ug per gram of tissue.

It seems as if success is on the way for BNCT. However, a number of pharmacological and pharmacokinetic questions remain to be sorted out. For example, is it best to give drug and irradiation as one treatment or as a number of multiple drug and radiation exposures? In the latter case, one may have a much enhanced probability of the drug being taken up by all cells in the tumor and at the same time reap the advantages of fractionated irradiation.

General Conclusions. Medical applications of nuclear technologies represent state-of-the-art technologies on behalf of human health. As in all modern biological research, these studies use sophisticated equipment, devices, and computers. Such modern day research requires ingenious ideas, dedicated individuals, and the necessary state-of-the-art instruments. A generic problem in Health and Environmental Research supported by the Department of Energy has been the low ratio of money for equipment to money for operations—approximately 5% for the past 7 years. To be efficient and to be at the state-of-the-art, requires a ratio of at least 10%.

APPENDIX I

CURRICULUM VITAE

Richard B. Setlow

Born: January 19, 1921, New York, New York

Education:

1941	A.B., Swarthmore College - Physics
1947	Ph.D., Yale University - Physics

Experience:

1943-1947	Yale Univ., Physics Dept., Instructor
1947-1956	Yale Univ., Physics Dept., Assistant Professor
1954-1959	Yale Univ., Director of Undergraduate Studies in Physics and in Biophysics
1956-1961	Yale Univ., Physics and Biophysics Depts., Associate Professor
1961-1974	Oak Ridge Natl. Lab., Biology Div., Biophysicist
1964-1969	Oak Ridge Natl. Lab., Biology Div., Group Leader, Biophysics
1967-1974	Univ. Tennessee, Professor of Biomedical Sciences
1969-1974	Oak Ridge Natl. Lab., Biology Div., Scientific Director Biophysics and Cell Physiology
1972-1974	Univ. Tennessee, Director, UT Oak Ridge Grad. Sch. Biomedical Sciences
1974-	Brookhaven Natl. Lab., Biology Dept., Senior Biophysicist
1975-	State Univ. of New York at Stony Brook, Adjunct Prof. Biochemistry
1979-1987	Brookhaven Natl. Lab., Biology Dept., Chairman
1984-1986	Brookhaven Natl. Lab., Acting Associate Director for Life Sciences
1986-	Brookhaven Natl. Lab., Associate Director for Life Sciences

Memberships: National Acad. Sci.; Biophysical Soc., Radiation Res. Soc.; Amer. Soc. for Biochem. and Mol. Biol.; Environmental Mutagen Soc.; Phi Beta Kappa; Amer. Acad. of Arts and Sciences; Amer. Assoc. for Cancer Research; Amer. Soc. for Photobiol.

Awards: Radiation Research Society Eleventh Failla Memorial Lecture, "The Repair of DNA -- Its Past and Its Future" at 21st Annual Meeting, St. Louis, Missouri, April 29 - May 3, 1973.

Finsen Medal for outstanding fundamental contribution to Photobiology and Repair of Nucleic Acids, at 8th International Congress on Photobiology, Strasbourg, France, July 20-25, 1980.

Recipient of the 1988 U.S. Department of Energy's Enrico Fermi Award for outstanding contributions to the fields of radiation biophysics and molecular biology.

Numerous publications in the field of DNA damage and repair.

Mr. SCHEUER. Thank you very much, Dr. Dick Setlow.

Now we will hear from Dr. Fred Morse, Associate Director for Research at Los Alamos. Please take the same five, six, seven, eight minutes that your colleagues have taken, and then I am sure we will have some questions for you.

STATEMENT OF DR. FRED MORSE, ASSOCIATE DIRECTOR FOR RESEARCH, LOS ALAMOS NATIONAL LABORATORY; ACCOMPANIED BY DR. RONALD WALTERS, PROGRAM DIRECTOR FOR BIOLOGICAL AND ENVIRONMENTAL RESEARCH; AND DR. GEORGE BELL, ACTING DIRECTOR, GENOME CENTER.

Dr. MORSE. Thank you, sir. With your permission, I would also like to introduce Dr. George Bell.

Mr. SCHEUER. By all means. Would you like to join us up at the witness table, Dr. Bell?

Dr. MORSE. Dr. Bell is our Acting Director of the Genome Center at Los Alamos and under his leadership—

Mr. SCHEUER. We're a little gun shy with Acting Directors.

Dr. MORSE. Right. I understand that.

Mr. SCHEUER. Nevertheless, we welcome you.

Dr. MORSE. I understood this committee in fact had been concerned about the lack of a permanent Director at Los Alamos, and what I wanted to do is to assure you that we have had extraordinary leadership under Dr. Bell, who has also been the leader of our Theoretical Division. The achievements I am going to describe to you are rather remarkable and I think Dr. Bell's stewardship of this program you will see has just been outstanding.

Mr. SCHEUER. Very good.

Dr. MORSE. I would like to have my full written statement entered into the record.

Mr. SCHEUER. By all means, so ordered.

Dr. MORSE. And I would like to have a short written record by Livermore for their achievements entered in, too, if I could please.

Mr. SCHEUER. No objection, so ordered.

[The material referred to above follows:]

Biomedical & Environmental Sciences Divisions
Lawrence Livermore National Laboratory

SUBMITTED FOR THE RECORD
TO THE HSST SUBCOMMITTEE

6 APRIL 1989

The Human Genome Project: Recombinant DNA Libraries for the Scientific Community, A Physical Map for Genes on Chromosomes 14 and 19, and Technology Transfer to Industry

The human genome project at Lawrence Livermore National Laboratory is a multidisciplinary team effort. It draws upon the Livermore matrix organization to bring together chemists, molecular biologists, physicists, mathematicians, computer scientists, and engineers in an interactive research environment. In the past two years, we have made excellent progress toward developing and applying new techniques to create a high resolution cloned physical map of an entire human chromosome (#19) and other selected regions of the human genome. With regard to recombinant DNA technology development, we created new recombinant vectors to facilitate cloning small amounts of highly pure chromosomal DNA obtained from our flow sorting instruments. Other vectors we made allow us to clone special regions of the genome and also very large fragments of DNA. Several of these vectors have been licensed to industry and will be commercialized.

As part of the very successful joint Livermore-Los Alamos National Laboratory Gene Library Project, both laboratories have constructed complementary libraries of all the human chromosomes using material purified from their unique flow-sorting instrumentation developed at these two laboratories. For the next phase of this project, Livermore constructed special "large insert" libraries of chromosomes 11, 19, 21, 22 and Y. The libraries are sent to the American Type Culture Collection repository for distribution to the worldwide scientific community and are also being used in our own efforts and those of our collaborators. In the last few years, recombinant DNA libraries from this joint effort have been sent to over 3000 laboratories and to almost every major country.

Beyond library construction, Livermore has applied its multidisciplinary research staff to develop new molecular biology processes, chemical reagents, software, and instrumentation to analyze cloned DNA fragments and to semi-automate the construction of the physical map. The chemical processes, reagents, and software have been licensed to a local biotechnology company. Our mapping approaches have been fruitful. We constructed sets of overlapping clones for five regions of chromosome 19 containing known genes and for a 600,000 base pair region located on chromosome 14. We are working with collaborators both in the U.S. and in Europe to further characterize the genes on our chromosome 19 map. The chromosome 14 region is uncharted and is serving a a source of DNA for collaborators to identify the genetic information therein. An important part of our program is the joint development with Los Alamos National Laboratory of a database system that will serve the needs of this project. We have been working very closely to insure that the data generated at both laboratories and throughout the DOE community will have a common format and universal accessibility.

It is clear from our past experience that cooperation among all funding agencies at the national and international level is necessary. An unbalanced funding structure among the agencies without a clear demarcation of responsibilities may not bode well for the U.S. genome effort. There is a need for multi-agency support and not for single agency domination. The latter might happen if the funding among agencies becomes grossly unbalanced. Moreover, the incremental funding for the first few years of the national effort should be appropriate to allow growth but also insure that monies will be spent wisely. We must not be faced with a situation of funding lower quality work for the sake of spending an allocation.

The human genome project has identified some interesting gaps in this nation's scientific manpower. Much of the application work to construct the physical map is tedious and repetitive. Thus, we have a need to draw upon individuals who may have only a two-year college degree, such as provided at the community colleges. At the present time, there is a shortage of people trained in biotechnology at this level. Moreover, it has been very difficult finding an adequate supply of postdoctoral students from United States' universities. Foreign students and visiting scientists are more readily available. If the United States is to maintain its leadership in genomics, we should allocate resources for our own training programs to prepare for future growth.

Finally, the global impact of the genome effort is obvious. Recent interactions with colleagues from Japan and Europe leave little doubt that strong genome programs will develop in other countries. If the United States' program is to succeed and dominate, we need the support of the Administration, Congress, and the people. Given the appropriate leadership, financial support, and ethical constraints, the genome project can and will provide innumerable health benefits for all mankind.

For further information on the Lawrence Livermore National Laboratory genome project contact:

Dr. Anthony V. Carrano
Biomedical Sciences Division, L-452
Lawrence Livermore National Laboratory
Livermore, CA 94550
415-422-5698
FTS 532-5698
FAX 415-422-2282

Dr. MORSE. The Human Genome Initiative is the most exciting thing I've ever been associated with in terms of its far-reaching aspects. We will gain a better appreciation of human variability. We will open broad insights into the age-old question of nature versus nurture. We will learn to customize medical care to the genetic predisposition of the individual. A better understanding of ourselves and how we and the rest of life fit into nature's pattern will certainly create enormous benefits.

But this vision can only be realized with a focused program. We must develop technologies to map and sequence the human genome efficiently, and we have to develop the computational capabilities to cope with the vast information stored in this blueprint.

Since October of 1986, DOE and the National Laboratories have been playing and must continue to play both a unique and vital role within the National Genome Initiative. I must emphasize that there are unique strengths and culture that both DOE and NIH bring to a National Genome Initiative.

At Los Alamos there is a sense of excitement and optimism among our scientists and technicians that is just enormous. The mood reminds our old-timers of the extraordinary days of the Manhattan Project.

Let me give you two examples. One of our people, Ray Stallings, was recently in the intensive care unit at our local hospital, and when Ron Walters went to visit him, discovered he was reducing data from this project I will describe in a few moments, with a temperature of 105 in the ICU. One of our technicians delivered a baby in the last two or three months. She also was found reducing data in the hospital bed just shortly after delivery. The enthusiasm among our scientists is extraordinary.

Mr. SCHEUER. Excuse me, Dr. Morse. I would have to tell you that the enthusiasm among Members of Congress for this Human Genome Project is just as extraordinary. We are absolutely hooked on it. Is that a fair statement?

Ms. SCHNEIDER. Yes.

Mr. SCHEUER. We really are. We are very excited about the potential of the Human Genome Project.

Dr. MORSE. I was asked to talk principally about the Genome Project and the Genome Center today, and so the other aspects of our research I will not be talking much about. My principal objective here today was to try and convince you that the National Laboratories shouldn't just be allowed to be a part of this National Initiative in a major significant way, but that we already are.

Scientists at Los Alamos in the last few months alone have accomplished the following:

1. The discovery of a single repetitive DNA sequence that marks the two ends of every human chromosome. These are called telomeres. Startingly enough, every vertebrate seems to have exactly the same sequence identifying the ends of the chromosomes in each of them. We have developed specific fluorescent tags for this sequence, and the color figures at the end of the text show these tags as small yellow spots in the orange mass of the chromosome.

[Slide.]

Dr. MORSE. That is upside down, but that's all right.

We have three chromosomes up there, from three different species of vertebrates: the human—I don't see the other—the Chinese hamster, and what is the third, Ron?

Dr. WALTERS. The human and the rat. The rat is on the left-hand side. The Chinese hamster is the large one on the right. The human cells are in the upper left-hand corner.

Dr. MORSE. These are chromosomes that have been isolated and they have been tagged with this tag that recognizes the specific sequence of the DNA, which is the end of the chromosome, which now means that there is a way to determine where the chromosome ends and where to quit looking for genes. The little yellow dots are those tags that show you where the ends of the chromosomes are.

The second achievement: In collaboration with the University of Washington, we have been able to make copies, or clones, of very large DNA fragments that contain these telomeres or the ends of these chromosomes, and they have done this for nearly every human chromosome. These clones are being stored and made available for research in the whole community.

Thirdly, it is likely that the DNA fragment that we have for the end of Chromosome 4 contains the elusive Huntington's gene, and we now have large numbers of those stored and available for distribution.

Fourth, we have invented a much faster technique for ordering these copies or clones. We expect to have over half of the Chromosome 16 sequenced—not sequenced, but the physical map by the end of this month.

We are collaborating with the University of Utah to combine our physical detailed map with their genetic map.

And, sixth, we have applied a computer learning technique to detect significant patterns in the repetition and sequences in DNA. This computer code now recognizes 100 percent of the sequences in a bacterium that code for proteins. When applied to the human genome, it reliably identifies all sequences that are now known to be genes. It also identifies a number of other sequences that we don't know the function of, but from what we have learned from this, it makes those sequences particularly interesting to follow up.

The DOE Laboratories have been able to progress this rapidly and effectively for two principal reasons: first, scientists at these laboratories have pioneered the development of many of the required technologies; and secondly, they are accustomed to assembling interdisciplinary teams, as Dr. Shirley mentioned. I will give you two examples of some of the earlier technologies that have been developed.

Flow cytometry is a technology in which cells or molecules are put into a flowing stream, passed through a laser beam, and the fluorescent tags identify what cell you've got. They can be sorted into special populations for future study. This technology was invented and developed at Livermore and Los Alamos, initially to study cell populations.

Los Alamos has been designated and funded jointly by NIH and DOE as a National Resource in Flow Cytometry as a result. We and Livermore also use this technology to separate specific human chromosomes and have been doing this for years as part of a DOE program called the National Laboratory Gene Library Project. These chromosome preparations furnish the purified starting material for the physical mapping of chromosomes in many laboratories.

The second example of our technological development is the use of computers and computational science to analyze genetic and other biologic information. Out of this initiative we formed GenBank, the national data base of DNA sequences which is funded by the National Institutes of Health.

Using our experience with computers and DNA sequences, our scientists have organized and analyzed sequences of the AIDS virus. This initiative has led the National Institutes of Health to establish at Los Alamos a National Resource for AIDS virus sequences. The rapid mutation of that virus is shown in the second figure at the end of your text and also here on the screen.

[Slide.]

Dr. MORSE. I don't have a time scale on that, but what you see is at a branch point, significant mutations. In fact, there are a number of mutations with each of those. The numbers at the apexes of the curves refer to the number of known single mutations within that virus prior to the branch point making what is called a significant difference.

As you see, the AIDS virus is mutating very, very rapidly and the Los Alamos Data Bank has been the principal source of information on this.

Mr. SCHEUER. Let me ask you a sort of a layman question. Zaire is way down at the bottom, and North America is about halfway up. Japan is a little further up the scale. Can you tell me in layman's language what that means?

Dr. MORSE. The tree that you see here are the mutations within the North American Continent alone. Zaire has a thing that looks very much like it, that would have been plotted on the lower half of that if there had been room. In other countries they are mutating in other ways.

Mr. SCHEUER. In other countries, what?

Dr. MORSE. They are mutating in somewhat different style. This is an extraordinarily rapidly mutating virus.

Dr. BELL. If I may add a comment, the isolate from Japan, by its sequence, has been found to come from San Diego. That is, by looking at the detailed RNA sequence of the virus and comparing it to those known for other isolates of the virus, you can say something about the place of origin.

Mr. SCHEUER. Is this an AIDS virus?

Dr. BELL. Yes.

Mr. SCHEUER. An AIDS virus in Japan has its origins in San Diego?

Dr. MORSE. That means it was carried by somebody from San Diego to Japan.

Mr. SCHEUER. From San Diego.

Dr. MORSE. In terms of the technology developments, we haven't stopped. There is new technology developing going on. Last summer, Los Alamos scientists fielded a prototype low-cost image acquisition and analysis system at the laboratory of Charles Cantor up at Columbia. The prototype has since been integrated into a data base management system. Part of the system has been developed in response to a prior national security emergency. Several companies have approached us and expressed a great deal of enthusiasm about putting this into the commercial market.

As a DOE center, Los Alamos was specifically charged with the responsibility of initiating partnerships and collaborations with private industry. A formal request has been made available to over 50 organizations who have expressed interest. In the Appendix of the testimony there is more detail on this.

The examples above illustrate what we believe is our major but not only role in the Human Genome Initiative; namely, the development of technologies that enable scientists to solve complex problems. While we have made significant progress on the scientific front, we do face some major obstacles. We don't have adequate staff to do a timely job with respect to technology development, nor are we able to take full advantage of our partnerships.

Mr. SCHEUER. Excuse me. What do you mean by a timely job?

Dr. MORSE. It's just that we can't do everything all at once in parallel, the way we would like to do. There is so much science to be understood prior to being able to develop efficient technologies, that those two things really ought to go in a parallel effort, and we simply don't have the personnel or the space to do both.

Similarly, we can't take full advantage of our partnership with industry, for lack of space principally.

We have an acute need for a facility that has adequate space for the industrial collaborators and meets modern airflow standards, includes hazard sensors, permits isolation of one experiment from another, and a long list of what modern facilities can do that our system built in the 1950s cannot do.

We have requested a Human Genome Laboratory building that would also provide modern space for the other OHER programs in environment and radiation research. This particular project has been validated within the DOE but it had not gone forward. I remind the committee that DOE is the key agency charged with research on health effects of radiation. Such research requires space compatible with safe handling of radioisotopes. Those isotopes are also used in mapping the human genome. If you saw the Nova program a week or two ago on the killer gene, you saw the application of radioisotopes to that effort.

My personal belief is that the Department of Energy needs at least $55 million in 1990 operating funds for work on the human genome. The HERAC group that you had heard about earlier—that is, the advisory committee—suggested that there should be a budget of $80 million. As I say, it is my personal belief that DOE needs at least $55 million in 1990 operating funds for work on the human genome. Much of that increase is for technology development and transfer of that technology to industry.

Additionally, DOE needs an increase in its basic environmental research if it is to understand some of the problems you talked to with Dr. Hunter earlier. That is to say, I would not be anxious to see money come to the Human Genome Project and be taken away from the environmental basic research.

Finally and very importantly, we at Los Alamos need at least $2.4 million in 1990 construction money to begin the new laboratory of which I spoke. Los Alamos is prepared to rapidly expand its research and development and technology transfer responsibilities. We have made significant discoveries in the last few months alone. We have created a Human Genome Center. We have excellent leadership. We are mapping Chromosome 16. We are developing new technologies. We are pursuing agreements with industry. I am convinced that this initiative is going to lay the foundation for medicine and biology of the 21st century.

Unlike many other research programs, which by the way I also support, this one is going to have tangible effects that we will feel in personal ways; if not directly, then friends and family will ultimately benefit from this.

Mr. SCHEUER. Could you describe those effects?

Dr. MORSE. Well, the medical effects that you have been hearing about for a long time—the question of understanding genetic predisposition to disease and therefore knowing that maybe changes in life style up front are appropriate for us. Some folks have different proclivities for various kinds of diseases based on their genetic makeup. Ultimately the question of being able to cure genetic disease is much further down the stream, but I am convinced that it's there.

I am anxious that together we get this project moving and going, and I would certainly like to see, in answer to one of your other questions, substantially greater DOE participation. I think we bring some unique capabilities to this program that the NIH has not over the years developed; principally, the team work approach and the interdisciplinary things that Dr. Shirley spoke of.

[The prepared statement of Dr. Fred Morse follows.]

Statement to the House Committee on Science, Space, and Technology Subcommittee on Natural Resources, Agriculture Research and Environment

Fred A. Morse
Associate Director for Research
Los Alamos National Laboratory

April 6, 1989

My name is Fred Morse, and I am Associate Director for Research at the Los Alamos National Laboratory. I am pleased to talk to you today about the Office of Health and Environmental Research (OHER) Program at Los Alamos. As requested, I will concentrate on the Human Genome Initiative, but first let me note the importance of other ongoing OHER projects, such as medical radioisotope research, radiation and work-place chemical health effects research, and important new initiatives in global environmental change, subsurface biology, and others. One very interesting story is our discovery of plant cells that accumulate large amounts of plutonium, barium, and other ground and water contaminants. Eventually the discovery of these cells may provide the basis for a safe, economical cleanup technology—a technology that would eliminate many kinds of waste at active industrial sites and help clean up toxic industrial waste or nuclear-materials waste at old sites. Having said that, I am very anxious to talk to you about the Human Genome Initiative, the most exciting and far-reaching program I have ever had the privilege to be associated with.

The Human Genome Initiative is creating the basis of biological and medical science for the twenty-first century. Genome refers to all the DNA in our chromosomes—the blueprints for producing the numerous proteins critical for life. Knowledge of the entire organization and sequence of our DNA will lead us to an understanding of what proteins are formed, how they are formed, and what events switch their production on or off. We will learn how the genetic instructions program the development of a fertilized egg into an adult organism, we will gain an enormous appreciation of human variability, we will open broad insights on the age-old question of nature versus nurture, we will develop tools for identifying, and in the future, potentially repairing, thousands of genetic diseases, and we will learn to customize medical care to the genetic predisposition of the individual. A better understanding of ourselves and how we and the rest of life fit into nature's pattern will create enormous benefits, both practical and psychological.

However, this vision can only be realized with a focused program. We must develop technologies to map and sequence the human genome *efficiently* and computational resources to cope with the vast information stored in this magnificent genetic blueprint. Consequently, the DOE and its National Laboratories are playing, and must continue to play, a vital role in the Human Genome Initiative—a role that I am delighted to have an opportunity to describe to you. Although I will emphasize discoveries and programs at Los Alamos, I want to enter a statement from our colleagues at Lawrence Livermore National Laboratory into the record regarding their recent work. David Shirley will cover programs at Lawrence Berkeley Laboratory, our other sister DOE Laboratory operated by the University of California. In addition, there are other important elements of the DOE program at the other national laboratories and universities. We also collaborate very closely with scientists within or funded by the National Institutes of Health (NIH) and the Howard Hughes Medical Institute (HHMI), and the National Science Foundation (NSF).

In April of 1987, a distinguished advisory committee to the DOE summarized our rudimentary understanding of the human genome by saying, "Our knowledge is equivalent to that of the fifteenth-century anatomists who knew about the major bones and organs but knew very little about their functions. The significance of most vital organs, including obvious ones, such as the liver and pancreas, or small ones, such as the pituitary and the adrenals, was completely unknown. Most important, even the simplest concerted functions of the body, such as provided by the circulatory system, were not mapped." The committee went on to recommend strongly that the DOE should take a leading role in developing technologies to map and sequence the human genome and in developing computational resources to organize and help understand the resulting data. The DOE National Laboratories provide the scale and scope of interdisciplinary capabilities in the biological, chemical, physical, mathematical, computational, and engineering sciences needed to achieve these goals. Partly as a result of these recommendations, the DOE established a formal Human Genome Initiative in fiscal year 1987 with a funding level of about twelve million dollars a year.

I am happy to report that, even during the short duration of this program, scientific discoveries were made that are analogous, perhaps, to earlier advances in anatomy that took a few decades to accomplish. Moreover, even the more modest advances are providing tools of unprecedented power for biomedical research and clinical practice. As a result, there is a sense of excitement and optimism amongst the scientists and technicians in the program that is characteristic of the most productive periods in science—the mood reminds our old-timers of the extraordinary days of the Manhattan project.

I am proud to speak for the scientists at Los Alamos, who, in the last few months alone, have accomplished the following:

1. Perhaps the most important event was the discovery of a single repetitive DNA sequence that marks the two ends of every human chromosome. (Startlingly enough, the identical sequence appears to be found at the ends of the chromosomes of all vertebrates). Our scientists have also identified unique sequences at the centers of each chromosome and have developed tags for the centers and the ends so that scientists all over the world can now identify those regions unequivocally. Until now, sequences marking the ends were unknown, so the boundaries of a physical map could not be located.
2. In collaborations with Washington University, Los Alamos scientists have been able to make copies, or clones, of very large (100,000 base pairs) DNA fragments that contain the ends, and they have done this for nearly every human chromosome. Those clones are being stored and made available for collaborative research.
3. For the case of Chromosome 4, it is likely that the DNA fragments we have cloned contain not only the end of Chromosome 4 but also the elusive Huntington's disease gene.
4. We have invented a much faster technique for ordering clones, that is, for putting different but overlapping DNA fragments in the correct order along the chromosome. We expect to have completed over half of the physical map of Chromosome 16 by the end of the month.

5. In collaboration with the University of Utah, we are combining our detailed physical map with their high-resolution genetic-linkage map. A genetic-linkage map is a statistical measure of the likelihood that two traits or genetic markers will be inherited together. Through comparison with a physical map we can determine actual distances, that is, an actual number of DNA base pairs, separating the markers or traits.
6. We have applied a computer learning technique to detect significant patterns in DNA. This computer code recognizes 100% of the sequences that code for proteins in the bacterium, *E. coli*, and when applied to the human genome, it reliably identifies all sequences known to be genes. In addition, it nominates a large number of sequences that are not now known to code for proteins.

Let me now give you more detail about what I have just said.

RECENT TECHNICAL ACHIEVEMENTS

It has been known for some time that the ends of chromosomes must have special base sequences, since otherwise a little DNA would be lost from the end of each chromosome during the duplication that precedes cell division. Last year, Bob Moyzis and colleagues at Los Alamos discovered that the end of each chromosome (the telomere) consists of a short DNA sequence repeated many times in succession. Moreover, they developed fluorescent and radioactive probes that would stick to and highlight this sequence wherever it was found. (As it turned out, this sequence was found only at the ends of chromosomes.) Now, the basic procedure in constructing a physical map is to cut copies of a chromosome into a large number (typically hundreds or thousands) of overlapping pieces; to make many copies of each piece by cloning it in bacteria or yeast cells; to recover and then partially characterize each clone; and, finally, to use the overlap to determine the natural order of the clones along the chromosome. The discovery and isolation of human telomeres has fundamental significance in that the natural boundaries of each human chromosome can be identified and mapped. Thus, the entire physical mapping process is facilitated by having definite places to start or to stop the map, and the telomeres provide such markers. In collaboration with Maynard Olson and colleagues at Washington University, St. Louis, Los Alamos scientists have established clones containing telomeres from most of the human chromosomes. Moreover, in some cases regions adjacent to those containing the telomeric DNA have been isolated, extending the physical map by roughly a hundred thousand bases from the telomere. For the case of human Chromosome 4, it is likely that one of the human telomere clones contains the elusive gene for Huntington's disease.

Thus, we see that the discovery of the telomere sequence has immediate spin-offs for the mapping of human chromosomes and for the identification of genes involved in hereditary disease. Research will carry the discovery in many other directions, and some of our scientists are already involved in doing so.

My second example concerns the use of computational science to analyze genome data. This is a field in which Los Alamos scientists and alumnae have played pioneering roles and, in many respects, have defined the state of the art. In recent research, Alan Lapedes and colleagues used computer learning techniques to detect significant patterns in the DNA of various genomes. In one such study the computer was trained to distinguish sequences of DNA that code for proteins from sequences that do not (or are not known to). For a simple genome such as that of the bacterium, *E. coli*, the computer is able to predict with virtually 100% certainty whether a sequence is coding or noncoding. In fact, it has learned that there are systematic patterns in coding sequences. When we try the same exercise for a complex genome, such as the human genome, the computer is once again able to identify sequences coding for proteins with high reliability. However, it also nominates a large number of sequence intervals that were not known to perform any coding function. What is their significance? Do some, in fact, code for previously unknown functions? Or are they fossils of previously functional DNA? Or, perhaps, viral sequences inserted in the human genome? There are more questions than answers, but machine learning approaches may provide powerful tools for finding answers.

As a final example, I direct your attention to the major physical mapping projects at LANL and LLNL, in which the Laboratories are developing physical maps of Chromosomes 16 and 19, respectively, by ordering overlapping clones. Lawrence Berkeley Laboratory is developing a map of Chromosome 21 and 22 by restriction enzyme techniques. The Laboratories are developing several new mapping strategies, evaluating them first with computational simulation and analysis, and then testing the more promising approaches on scales appropriate for chromosome mapping with specific aims toward automating the mapping process.

At Los Alamos we have initiated a novel mapping approach that uses natural features of human genome organization to simplify the mapping process. To give you an idea of the scale of this process, we have isolated and cloned about 25,000 overlapping fragments that span Chromosome 16 about 10 times over. To obtain fragments that we know are not contaminated with DNA from other human chromosomes, we used flow cytometry to sort Chromosome 16 from the others. We are presently engaged in the laborious task of characterizing a large number of those clones and have developed a system for partially automating the process. Characteristics of a clone become apparent as a pattern of dots or bands on a photographic film. In our automated system, an image of the film is captured by a TV-like camera and sent to a computer for processing. The result is a set of numerical characteristics of the clone. Those characteristics are, in turn, compared to the characteristics of other clones in the search for overlap, which is the basis for ordering the clones thus creating a physical map. I caution, however, that the final completion of the chromosomal map is expected to be a more lengthy process because the presence of unclonable fragments leave gaps in the information.

To exploit our resources optimally, we are collaborating with Ray White and colleagues at the Howard Hughes Medical Institute at the University of Utah, comparing and integrating the developments of our physical map and their high-resolution genetic-linkage map. The combination of these complementary methods provides a direct path to physically locating and characterizing specific genes, as well as the variations in those genes that cause hereditary disease or predisposition to such disease. Also, excellent collaboration exists between the experimental and theoretical scientists in the mapping projects at Los Alamos and at Livermore. There has been a healthy exchange of information between the Laboratories.

HISTORICAL PRECEDENTS

How have the DOE Laboratories been able to progress so rapidly and effectively in the Human Genome Initiative? First, scientists at these laboratories have pioneered the development of many of the required technologies. Two examples must suffice.

Flow cytometry is a technology in which cells, cellular fragments, or single molecules in a flowing stream are passed, one at a time, through a focused laser beam. The cells or molecules are tagged with specific fluorescent dyes and emit characteristic radiations when they pass through the laser beam. On this basis, they can be enumerated and also sorted into special populations for future study. The technology was invented and developed at LANL and LLNL initially to study cell populations. It is now possible to characterize and sort several thousand cells per second. Los Alamos skills in this field have been recognized, and the Laboratory has been designated and funded by the National Institutes of Health as a National Resource in Flow Cytometry. As mentioned above we and Lawrence Livermore National Laboratories use this technology to separate specific human chromosomes and have been doing this for several years as part of the DOE program called the "National Laboratory Gene Library Project." Chromosome preparations obtained in this program have furnished the purified starting material used for the physical mapping of Chromosome 16 and 19 and for the mapping of other chromosomes in other laboratories

The second unique component of our strength is the use of computers and computational science to analyze genetic and other biological information. About twenty years ago our mathematicians began to characterize the similarity of one sequence to another. As DNA sequences became numerous, our scientists became convinced that a computer database of all published sequences would be essential. Walter Goad and others at Los Alamos set about constructing one and then requested and received funding for the effort from the National Institutes of Health. Out of this initiative was born GenBank, the national database of DNA sequences. Compilation of the data is a collaborative effort between Los Alamos, the European Molecular Biology Laboratory, and the DNA Database of Japan. The data are distributed in the U.S. by our corporate partner, Intelligenetics. In addition to organizing GenBank, our scientists have developed new computer programs, including the machine learning approaches noted earlier, for analysis of the data.

Our long experience with computers and DNA sequences is now leading us in other directions. For example, our scientists have organized and analyzed sequences of the human immunodeficiency viruses (HIV) that cause AIDS, as well as other related retroviruses. This initiative has led the National Institutes of Health to establish at Los Alamos a National Resource for HIV Sequences, which has already had a substantial impact on national and international AIDS programs.

In another direction, Los Alamos scientists are creating a new type of "relational" database specifically designed to handle the complex, multileveled information generated by physical mapping efforts—this under DOE funding for the Human Genome Initiative. Recently, a distinguished group of scientists at a workshop funded by DOE, NIH, and HHMI recognized the effort and designated it as the "pilot project" for physical mapping databases.

We, thus, see that Los Alamos theoreticians have continuously led in the development of new resources for the organization and analysis of genome information. They are eager to continue to do so.

A second reason that DOE Laboratories are able to move rapidly with human genome projects is that they are accustomed to assembling interdisciplinary teams of outstanding scientists and engineers to solve important national problems. Unlike universities, this approach is a standard way of doing business at the Laboratories. To find computer scientists working in a team with molecular biologists is no surprise at Los Alamos.

THE HUMAN GENOME PROGRAM AND THE DOE MISSION

It is natural that the Department of Energy—with its national laboratories focused on large, multidisciplinary programs—should have a prominent role in the Human Genome Initiative. In particular, the Human Genome Initiative will have a significant impact on one major mission of OHER—namely, to understand the effects of low levels of radiation and energy-related chemicals on human genetic material and human health. Past and continuing contributions of DOE to this mission are described in Appendix II. The Human Genome Initiative will give us a far greater ability to understand and assess the effects of human heterogeneity on sensitivity to radiation and other hazards. For example, the cells of most people are able to repair minor damage to their DNA. But the cells of some people do not, and this greater sensitivity needs to be understood and considered with regard to workplace health standards.

TECHNOLOGY DEVELOPMENT

We are in the middle of a revolution in experimental methodologies associated with recombinant DNA technology. Los Alamos has established a vigorous, multifaceted program to develop new technologies that take full advantage of the recent advances in experimental molecular biology. Our program involves collaboration across the Theoretical, Life Science, Physics, Chemistry and Laser Sciences, and Mechanical and Electronic Engineering Divisions at Los Alamos and with various universities and industrial partners outside. For example, last summer Los Alamos scientists field-tested a prototype low-cost image acquisition and analysis system at the laboratory of Charles Cantor at Columbia University. This prototype is part of the automated system mentioned earlier that analyzed the film images characterizing individual clones. Dr. Cantor remarked that "this system is better than anything the Japanese have and is a fraction of the cost." The prototype has since been integrated into a database management system with a variety of computer tools for data acquisition, storage, management, analysis, and visualization. Parts of the system had been developed in response to a prior national security emergency. Several companies have approached us and expressed a great deal of enthusiasm about developing a commercial product.

The sensitivity of flow cytometry has been further extended at Los Alamos to permit the detection of single molecules of modest size. We are currently trying to adapt this technology to the sequencing of single DNA molecules at a rate far exceeding that now attainable and at a much lower cost. It is generally agreed that current technology is not adequate for full-scale sequencing of the human genome and that, initially, the Human Genome Initiative should place heavy emphasis on technology developments that improve the rates of sequencing and reduce its cost. We believe that our approach, based on single molecule detection in flow cytometry, is one of the most promising.

Scientists at Los Alamos are attempting to use micro-robotics to manipulate single cells. This effort was developed independently of the Human Genome Initiative, but it is viewed as a potentially very useful tool for manipulating and analyzing single molecules.

INDUSTRIAL PARTNERSHIPS

As a DOE Center for Human Genome Studies, Los Alamos has been charged with the responsibility of initiating partnerships and collaborations with industrial participants to ensure technology transfer to the private sector. We have implemented a vigorous program to inform potential industrial partners of the scientific and technical activities of the DOE Human Genome Initiative, in general, and the Los Alamos projects, in particular. In December, at a Los Alamos-sponsored workshop, we provided a technical overview to a group representing over 25 industrial organizations. A formal request for proposals has been made available to over 50 interested organizations. This initiative ensures the opportunity for efficient transfer of new technology to the private sector and, ultimately, to the public market.

SUMMARY

The examples above illustrate what Los Alamos believe is its major role in the Human Genome Initiative– namely, the development of technologies that enable scientists to solve the complex problems impeding rapid progress. This role can only be accomplished by strong, multidisciplinary teams of scientists and engineers with varied backgrounds in the fields of experimental and theoretical biology, mathematics, physics, chemistry, computer science, and engineering.

While we have made significant progress on the scientific front, we do face some major obstacles. We do not have adequate staff to do a timely job of technology development nor are we able to take full advantage of our partnerships with industry. To continue the productive research I have described, to convert our technology into practical tools, and to transfer that technology in a timely way to American industry, we need a substantial increase in staff and space.

We have an acute need for a facility that has adequate space for industrial collaborators, meets modern airflow standards, includes hazard sensors, and permits isolation of one experiment from another. We are now seriously overcrowded. To perform the work that needs to be done, we have requested a Human Genome Laboratory building that would also provide safe space for other OHER programs in environment and radiation health research. I remind the committee that the DOE is the key agency charged with research on health effects of radiation. Such research requires space compatible with safe handling of radioisotopes. Those isotopes are also used in the mapping of the genome, as some of you may have seen described on the NOVA program broadcast on March 28. To avoid the hazards of working with viruses, radioactivity, and genetically engineered microbes, we need very clean work areas that only a modern facility can provide.

I believe that DOE needs at least $55M* in 1990 operating funds for work on the human genome. Much of the increase is for technology development and transfer to industry. Additionally, given the importance of the work, DOE needs an increase of $10M for environmental research to find and exploit ways to clean up waste and reduce the production of waste. Finally, and very importantly, we at Los Alamos need $2.4M in 1990 construction money to begin a new laboratory. It has a total estimated cost of $75M, with a funding profile given in an appendix.

This Laboratory is prepared to rapidly expand its research and development and its responsibilities in the Human Genome Initiative. At the present time our program includes the physical mapping of Chromosome 16, the development of advanced technologies for sequencing single DNA molecules and for mapping, as well as the development of databases and advanced computational tools for the analysis of vast amounts of genome data. We have created a Center for Human Genome Studies. We are aggressively pursuing collaborative agreements with private industry (see appendix), both to strengthen our research and development program and to foster the transfer of technology to the private sector. I am convinced that the Human Genome Initiative will provide the basis of medicine and biology in the twenty-first century. Let us get on with it.

ACKNOWLEDGEMENTS

I want to thank Dr. Ronald A. Walters, Dr. George Bell, Dr. C. Edward Hildebrand, and Dr. Thomas Marr for their efforts in writing this document.

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* The DOE Health and Environmental Research Advisory Committee recommended $80M.

Resume
Dr. Frederick A. Morse
Los Alamos National Laboratory

Dr. Fred Morse joined the Los Alamos National Laboratory in 1980 and has since held a number of research and management posts. His current position is Associate Director for Research, a position he has held since February 1987.

As Associate Director for Research, Dr. Morse has line management responsibilities for six technical divisions (Chemical and Laser Sciences, Isotope and Nuclear Chemistry, Life Sciences, Medium Energy Physics, Theoretical, and Physics); four scientific centers (Center for Materials Science, Center for Nonlinear Studies, Los Alamos Neutron Scattering Center, and the Center for Human Genome Studies); and a world-used accelerator research resource for nuclear and particle physics (Los Alamos Meson Physics Facility).

The Center for Human Genome Studies, the Life Sciences Division and part of the Theory Division are all heavily involved in structural biology, genetics, and mapping and sequencing research. These organizations include the National Resource for Flow Cytometry, GEN Bank, and the National Laboratory gene library. The Life Sciences Division is also conducting research in physiology, biochemistry, and cell biology.

The Isotope and Nuclear Chemistry Division is involved in many projects, among them production and research with radionuclides used in nuclear medicine.

The Physics Division includes in its activities research with magnetoencephalography and development of automated electrophoresis instrumentation.

The Chemistry and Laser Science Division has an experimental program to develop sensitive detection and sorting methods to identify single base pairs.

The Directorate has about 1500 scientists, tecnicians and office staff.

Mr. **Scheuer**. Thank you very much, Dr. Morse.

Dr. Setlow, can we get you back to the table here?

All right. I am going to recognize our Ranking Minority Member, Claudine Schneider of Rhode Island, for questions.

Ms. **Schneider**. Thank you very much, Chairman. I appreciate that because I do have to run off to yet another hearing this morning. But I realize that the administration witnesses earlier had made some comments about radon, so excuse me for shifting gears here a moment from the Human Genome Program to some questions relating to the indoor air pollution and radon.

I think that speaking of human health, we have awareness now that somewhere between 12,000 and 20,000 of the 120,000 lung cancers that occur each year are attributable to radon exposure. And DOE, over the last couple of years, has been increasing its radon research on how it gets into the homes and exactly what the health effects are. And I think that is very encouraging. That's the good news.

Now, the bad news is that in separate part of DOE's budget, which is the energy conservation portion, they have allowed their radon mitigation research to dwindle to just about $100,000. And I am wondering—Lawrence Berkeley Lab has the responsibility for much of that radon work—what can you possibly do for $100,000?

Dr. **Shirley**. I think that's a rhetorical question. You can't do much for $100,000. That will support about one FTE. That is essentially a shutdown-level budget.

Ms. **Schneider**. Well, that's exactly what I needed to know.

Has this budget been fluctuating in the last couple of years?

Dr. **Shirley**. It has tended to show monotonic decline from what we would desire in terms of what we believe to be the magnitude of the problem. We don't think it ever was as large as the mortality statistics that you cited would indicate. We would like to see it increasing rather than decreasing.

Mr. **Skaggs**. Would the gentlewoman yield for a moment?

Ms. **Schneider**. Yes, I would.

Mr. **Skaggs**. I am not familiar with the term "monotonic" as you used it there. Could you enlighten me? It hope it is not monotonous.

Dr. **Shirley**. It means it tends to decline without increasing, or increase without declining. But the former is the case here.

Ms. **Schneider**. Do you think that this is an area in which Lawrence Berkeley might be able to productively expand your research to help us reconcile energy efficiency with indoor air quality?

Dr. **Shirley**. Yes, I do. We have a strong Energy- Efficient Buildings program which is very naturally coupled to the indoor air quality issues, and we believe that these programs have a synergistic relationship.

Ms. **Schneider**. Are you aware that the kind of work that you're doing is being done anywhere else?

Dr. **Shirley**. No, it is not. It is unique.

Ms. **Schneider**. So that if we are concerned with mitigation of the problem of radon, then clearly we have to make sure that there is an increased expenditure of funds for your lab for this area.

Dr. **Shirley**. We believe that it is important to increase funding in this area, yes.

Ms. SCHNEIDER. The other thing that I wanted to touch base on is that medical biotechnology is becoming extremely competitive, particularly in the international arena, and I wondered if you could tell us what some of the National Labs are doing about technology and information transfer in the area of the human genome, particularly information transfer.

Dr. SHIRLEY. Well, information transfer has been one of the fortes of the program, particularly at Los Alamos over the years. In GenBank they have generated an enormous amount of data on the human genome.

We are beginning to participate in a major way in this activity as well because it is a major issue how we are going to be able to deal with the enormous amount of data that are generated in the Human Genome Project, not only storage but access, sorting, and so forth. It is actually quite an important and challenging problem in software development to be able to understand these issues.

Mr. SCHEUER. Yes, Dr. Morse.

Dr. MORSE. I would like Dr. Bell to respond to that question, too, if he may. He has been spearheading one of our projects in tech transfer with industry associated with our Center.

Ms. SCHNEIDER. Thank you.

Dr. BELL. First of all, to come back to your emphasis on the information transfer, as Dr. Shirley indicated, we have for the past six years been the national center for accumulating DNA sequences in the computer data base and distributing them to researchers everywhere.

We have an industrial partner in that, in Telegenetics in California, and in addition the information and software is marketed by many U.S. companies to researchers in the field. We are also much impressed by the importance of assembling a data base of not sequence information, but clone information pertinent to the genome program. And we are starting a pilot program to establish the data base which again will be a national or international resource for workers in the field.

We think that we have unique experience in the management of large genetic data bases which will be very important to the Human Genome Program.

In addition, our Center was charged specifically when it was established by the Secretary of Energy, to pursue technology transfer arrangements with private industry. We have issued a request for proposals. We will soon be entertaining formal proposals from a variety of industrial partners for participation in our program at many different levels—the informatics advanced sequencing technology and advanced mapping technology are all going to be subjects for industrial partnerships, we believe, within this year. These will be structured so that it will enhance the competitiveness of American companies.

Ms. SCHNEIDER. Okay, good. You answered my other question.

I think that's all I have right now, Mr. Chairman. Thank you kindly.

Mr. SCHEUER. Thank you very much. Now we will go to David Skaggs of Colorado.

Mr. SKAGGS. Thank you very much, Mr. Chairman.

I apologize I was not here, Dr. Shirley, for your statement and wasn't here also when Dr. Hunter was present. I am new to the subcommittee and am taken with the level of research in areas outside the normal purview that I associate with the Department of Energy that you all are involved in.

Could you give me, whoever might feel most capable of doing this, a brief history of the Department of Energy's work in this adjunct field, if you will, of biological and environmental health?

Dr. SETLOW. Yes. I think this began with the Atomic Energy Commission, with its concern as to the health effects of ionizing radiation. And the beginning of the interest in biology came from a need to assess what the health effects were of ionizing radiation.

That quickly led to an interest in developing radioisotopes that could be used to investigate biological and physical processes and also to be used for medical purposes, and that began the whole involvement of the Atomic Energy Commission in medical processes as well as biological ones.

It also became rather obvious early on that one was not going to be able to obtain the information needed to evaluate what happens to people by looking only at people, because they are not very good experimental subjects. And so that began a large body of research not only on animals, small animals, but also a large body of research on molecules; in particular, nucleic acids, the genetic material of cells. And it was really work at the National Laboratories that laid the foundation for our understanding about what the effects of radiation, for example, were on the genetic material.

That laid the foundation, just to give you a history, for the work of the National Cancer Institute, which then finally was convinced that things that damaged DNA were bad for you, and that led to a whole plethora of research on genetic effects of chemicals and radiation.

And so the origins of DOE's involvement really go back to nuclear energy: How can it be harnessed for good? What can we say about its bad aspects? And in the process, they got interested in nucleic acids and chromosomes, and therefore naturally genome and, for the good effects, medical applications of nuclear technology.

Mr. SKAGGS. I appreciate such a succinct history. I can understand Swarthmore's pride. That's coming from a Wesleyan graduate, too.

One of the things, harkening back to our days in school, I did a paper in the early '50s, the mid-50s, I guess it was, looking at the then state of research that had been published in journals I could understand at that point in my life about the health effects of radiation, and continued over the years, now represent an area which includes one of the Department's principal weapons fabrication plants at Rocky Flats.

I get a lot of concerned questions from the people I represent about what we really know at this point about the both incremental and cumulative effects of various exposures. My lay sense of the state of the art there has been that every year we've sort of had an order of magnitude reduction in the scientific and medical community's standard for exposure that is not health-threatening.

I am wondering again, whomever of you may feel the urge, if you could address yourself to the history of our increased understanding of safe exposure levels, if there is such a thing; where we are now in understanding cumulative versus one-time exposures; and what level of confidence the scientific community now has that we have it right.

Dr. SETLOW. One of the problems is that the levels of exposure that we usually are concerned about in everyday life are very low levels of exposure, and it is not easy—as a matter of fact, it might not be possible easily to do such experiments at low levels of exposure, except by special tricks.

Let me give you an example. Reference was made to the Japanese populations exposed to the atomic bomb that have been studied under the auspices of the Department of Energy to look for mutations in the offspring of irradiated parents.

No statistically significant mutations have been observed in those offspring. But molecular biology techniques have been able to observe mutations in the blood cells of individuals who have been irradiated, but not yet in the progeny. These were experiments that were carried by Livermore on a particular blood protein.

The difficulty with all these exposure levels is that as time goes on, we find more and more natural sources of radioactivity, such as radon, and the average dose to which people in the United States are now exposed has gone up by at least 50 percent or more just with the discovery of the real hazard of radon.

As people get an appreciation or an extrapolation of the hazards of radiation, usually the levels to which one advises exposure go down. That's not because anyone has any good data. They are extrapolated from high doses. And the idea behind the genome project was an attempt to observe low levels of radiation.

We can observe big molecules like DNA and find out if their sequence changes much easier than we can observe people. We can observe many, many DNA molecules; we cannot observe many people.

I will give you an example. In the exposed Japanese, exposed to the atomic bomb, the number of cancers found attributable to radiation is probably less than 1,000. That is a very small number.

Mr. SCHEUER. Of the several hundred thousand who died?

Dr. SETLOW. Well, the ones that died did not get cancer. They were killed. Only in the survivors. It's a small number, of the order of 1,000.

Mr. SCHEUER. In other words, only 1 percent of the survivors who were seriously affected, who were within the radius, whatever that acutely affected radius was, only 1 percent of them died of cancer?

Dr. SETLOW. No. I'm not sure of the percentage, Mr. Scheuer. It's 1,000 is the number.

Mr. SCHEUER. Oh, 1,000 of the several—-

Dr. MORSE. The several hundred thousand.

Mr. SCHEUER. Oh, I see.

Dr. SETLOW. But it's still several hundred thousand. It's a small number.

Mr. SCHEUER. Well, several hundred thousand died and there must have been a population of millions, several millions I would think within that severely afflicted area.

Dr. SETLOW. The problem is that there's a big background incidence of cancer in the entire population, the origins of which we don't really understand. The increment due to radiation is relatively small, and it is only in that particular population that has been so well studied that you can pick these out.

Mr. **Scheuer**. What you're saying is, it's virtually infinitesimal.

Dr. **Setlow**. In terms of numbers; yes, that's true.

Mr. **Scheuer**. Well, what are the implications of that fact?

Dr. **Setlow**. That means it's very hard to get good numbers because it's so small, because the background rate of cancer among all populations is very, very low.

I'm sorry. The background rate is high enough so that it is very difficult to detect the effects of low doses.

Mr. **Scheuer**. Now, wait a minute. Are you saying that the Hiroshima atom bomb produced low doses?

Dr. **Setlow**. No, no. I'm saying those were doses in the neighborhood of let's say 50 to several hundred rads. The exposures that we speak about environmentally are of the order of a few tenths of a rad per year. So it would take lots and lots of years for anyone to accumulate the kinds of dose they would have in Japan, and spread over many years.

The reason it is relatively easy, even with these small numbers in Japan, to detect the induced cancers, is that their irradiation came at all one time. And so it's possible to follow those individuals as a so-called cohort and observe the increase.

But for most of us who are exposed environmentally, whether it's a tenth of a rad or two-tenths, it's almost impossible.

Dr. **Morse**. I would like to expand on some of this, if you don't mind. Dr. Setlow said that the background had gone up. That isn't really what he meant. He meant that our understanding of what the background is has changed, and it's higher than what we once thought of the radon effect.

The other point I wanted to make is that there are a few studies in which special circumstances allow us to get better statistics because the numbers of affected people have grown. There is a study going on with Los Alamos and the University of Colorado researchers, looking at uranium miners for example. A uranium mine collects a lot of radon gas. It's a natural decay product, and of course it's trapped in that mine so that the densities are relatively high, higher than they are in the homes that we've heard about.

The curious thing is in following that, smoking miners have effectively all had lung cancer. The miners who did not smoke have no change in lung cancer relative to the rest of the population, indicating that there are a lot more things that just radiation that go into a lot of these diseases. That is, for some reason there's a symbiosis or a connection between smoking and radiation that makes it much worse than either one alone.

Mr. **Skaggs**. Let me get back to the fundamental question. We continue to have standards for safe levels of exposure talked about as if we really knew what we were talking about there.

Do we? And what is your level of confidence that there is some medically scientifically meaningful significance to those standards, or are they our best clumsy shot at trying to be careful?

Dr. **Morse**. Let me try that one first, and then these two guys can correct me. It is my belief that we have tried to set those standards very, very conservatively, based principally on animal studies. For example, this Japanese study that was referred to indicates that people are perhaps a factor of 2 less susceptible than the mice that we've been studying and using as setting standards for us.

But again, when you deal with very low doses for a very long time, relative to a background that exists everyplace in the world at different levels, but nonetheless always there—and we're talking about small changes relative to the background—it is very difficult to get anything terribly definitive.

And so we believe things are principally conservative, maybe more conservative even than we thought, if the Japanese study is relevant.

Mr. SKAGGS. Looking at the principal concern in my area related to the Rocky Flats plant, which is inhalation of microscopic plutonium, what do we know about there being a "safe" level of exposure in that ingested form of plutonium of essentially low-level alpha radiation as I understand?

Dr. MORSE. Well, we don't know nearly as much as we'd like to know. The largest body of evidence that I know about deals with people who have been working with plutonium at Los Alamos since 1943. There, every one of the plutonium workers is followed throughout their life. We keep statistics on essentially every facet of their health. And when they die, those people are all autopsied to try and understand what the plutonium burden in those bodies is.

The evidence is that at least at the levels they have been exposed, which of course were as controlled as we knew how to make them and controlled as we understood them to be important, particularly in the '40s, is different than we understand them today, there is not an awful lot of change. In fact, a good many of those people on a statistical basis seem to be healthier than the average public. That's not quite fair because there is some kind of a selection process that brought them into being healthy workers in the first place. But certainly it's not a dramatic effect or we would see it in the statistics.

Mr. SKAGGS. Dr. Shirley, did you want to comment on that?

Dr. SHIRLEY. Yes. I would just like to make the comment that you are really asking questions that are very far into the area of relative risk assessment. If you just consider risks from radiation alone, there are a number of other sources of radiation that are comparable to or exceed the risk that one might have at the lower limit of the acceptable level.

Mr. SKAGGS. I understand that. Believe me, it does not persuade my constituents very much to tell them by living at an elevation of 6,000 feet, they're deliberately exposing themselves to several orders of magnitude greater than what they might get from kicking up the dust around Rocky Flats.

Scientifically, it's compelling. Emotionally, they choose to be there; they don't choose to have the plant affect them.

One final question, if I may, Mr. Chairman. As I'm sure you are aware, you are painted in some sense with the broad brush of public skepticism about the Department of Energy, and that your research in these areas is regrettably, in some minds, tainted by that.

My question is: How do you feel about the proposals to transfer out of the Department of Energy the primary responsibility for tracking the long-term health effects on the worker population in particular and to give it a sense of independence from the Department that in the public's mind is primarily responsible for building nuclear weapons?

Dr. MORSE. That is, I guess, a weapons question. So from the weapons laboratory, perhaps I should try to answer it. It's a hard question.

I think from a technical perspective, I don't accept the notion that we try to cover anything up or anything of that sort.

Mr. SKAGGS. I don't mean to suggest that you do.

Dr. MORSE. I understand that.

I think in the perception of the public, it may well be that if the autopsies and the tracking that I was referring to were done by a different organization, it might well seem more credible. I don't think it would be done any better, but I believe you are right; it would be more credible.

Now, that's my personal opinion. I can't say I am speaking for DOE, obviously, but I think that's likely to be the facts of the matter.

Mr. SKAGGS. Just taking it one step further, could we be sure that the same capabilities and developed expertise that you are bringing to this particular task could be found elsewhere if we chose to move that responsibility elsewhere?

Dr. MORSE. Well, it would take close coordination, clearly, between the organizations that have the records of what various worker exposures have been over all of the years, and an assessment team.

But the Department of Energy has a lot of assessment teams that come in from the outside routinely. We have a few dozen of those come to the laboratory every year for looking at one aspect of our science or technology or another. And so I am certain that that could be done and it could work well.

Mr. SKAGGS. I take it that Dr. Hunter is the departmental official that has responsibility for all of the areas of work that we have been talking about this morning?

I am seeing some going up and down and some going back and forth.

Dr. MORSE. For the areas of work we've been talking about principally, yes.

Mr. SCHEUER. Yes. And just let me add that I will ask unanimous consent for the record to be kept open for 10 days or two weeks so that members can ask Dr. Hunter questions that they may not have had the opportunity to ask.

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. SCHEUER. There being no objection, so ordered.

Mr. SKAGGS. Thank you.

I was engaged in a brief discussion with Dr. Hunter yesterday morning about one of his other projects with the SSC, and I hope his attentions are not diverted to that, that they are neglecting your work.

I might just comment that somehow he felt it was appropriate to spend over a million dollars sending out environmental impact statements on the SSC to about 16,000 people that probably didn't need or want them, at a cost or for an amount of money that you probably could have put to better use. So you might ask him for small change the next time you see him. And good luck with your endeavors.

Thank you, Mr. Chairman.

Dr. MORSE. Sir, I would like to make an offer. I know that the folks at Colorado are very concerned about the plutonium burden. And we do have a great deal of information at Los Alamos. I would like to arrange and invite you out to talk to folks at some length, you and your staff or whoever you'd like to bring along, to find out what it is we do know in some detail.

Mr. SKAGGS. Well, I appreciate the offer. I accept and would like to get down there to do that. If I might reciprocate, the Governor of Colorado and myself have an environmental monitoring council, a citizens group essentially, that attempts to be a broker of good information to the concerned public in that area. And perhaps after I see what you all have to present, we could get you to come up to Colorado and make a presentation to that group and inform the public a little bit better.

Thank you very much.

Mr. SCHEUER. Thank you, Congressman.

A couple of questions for the entire panel, and then I'll have a few separate questions. What kind of technical innovations do you think would be appropriate and desirable to enhance the success-like prospects of the Human Genome Project? If you were in the catbird seat somewhere, what would you say ought to be done to move the entire program forward, whether the work is being done in DOE or done at NIH?

And what special provisions ought to be put in place to ensure that the technology that is developed through this research program is transferred as expeditiously as possible from the labs to the private sector?

Dr. SETLOW. If I can make a general comment, and then I'll turn it over to my genome experts to my left. That is, I would like to quote a remark that was made by a very famous biochemist, Erwin Chargaff from Columbia University. When faced with a similar kind of a question on how to spend money and how many man years would do something he said, "No, no. That's the wrong question. It's not man years." That was before women were recognized in science. "It's not human years. It's brain years that count."

And what is needed ultimately to speed up some of these processes are new ideas, not just more and better technology. The only way we are going to get that is to convince people that this is an important kind of a project and they should put their brains to it to figure out short cuts that no one has thought about yet. That's what I mean by brain.

Dr. MORSE. While I don't disagree a bit with him, I don't think ideas are limiting us at the moment. There are lots of them. And Dr. Shirley spoke about the interdisciplinary character of DOE with respect to NIH's principal investigator approach. I regard them both as very, very important, and separate and unique characteristics of the two organizations.

But so far as tech transfer and developing technologies, I think that is a place where DOE has played a remarkable role in the past. I see lots of ideas out there that we would like very much to pursue. We have two people doing jobs that probably ought to be 10 and 15-member teams working on them.

So my answer to your question is that this balance that you once referred to with respect to DOE and NIH, I don't want to argue that NIH's should be less because there are a lot of good ideas at NIH. Certainly I think that we need substantially more to pursue the questions of technology development.

Dr. **Bell**. Yes. I think almost all the advisory committees which have addressed this problem for the National Academy of Sciences, for the Congress, the OTA Report, have emphasized the importance of heavy investment at this time in the early years of the program in developing the appropriate technology for large-scale manipulation, the determination of sequences, maps, and so forth.

In many instances, the technology for the small-scale determination of genomic characteristics is in hand, but in moving forward in orders of magnitude of more information, one needs to introduce a much higher level of automation in the DNA handling and preparation steps. One needs to worry about substantial repositories of information and clones. And these matters require an early attention because they will have long-term payoff in the rest of the program.

In our own laboratory, we see several areas deserving of much more attention now. As I mentioned, the automation of the DNA handling process, especially in physical mapping.

Mr. Hunter emphasized the importance of new discoveries for advanced sequencing methods. But if we look at not the sequencing problem but the so-called mapping problem, which is an earlier step than the sequencing business, we have very large programs relative to single investigator scale, but not as large as they should be, at Los Alamos, at Livermore, and at Lawrence Berkeley Laboratory to map particular chromosomes.

The rate limiting feature of those programs right now is simply lack of manpower or person-power, if you will. We know how to do them faster. We know how to do them better. We don't have the funding and resources to get on with it.

Mr. **Scheuer**. To implement them.

Dr. **Bell**. Right.

Mr. **Scheuer**. Dr. Setlow was saying the main thing, the main determinant of progress is creative human beings and innovative creative ideas. Correct?

It seems to me that we have them in amplitude. We have a great well, let us say, of creative innovative ideas and I think, as I interpret it, Dr. Bell, you are saying that we don't have the manpower to develop those ideas and, from prior testimony, we don't have the plant and equipment and space in which additional personnel could be working to implement those creative ideas.

The one thing that doesn't seem to be a bottleneck is the absence of creative ideas. The bottlenecks, as I am perceiving them from your testimony, from other folks we've chatted with, the bottleneck comes in the implementation and the development of these ideas and the refining of these ideas. And for that, both further personnel is needed and further plant, equipment, space is needed.

But the ideas, as I get it, are there. We have a very creative scientific community, particularly at the top echelons. They are generating a lot of creative ideas, particularly in this exciting area of human genome research which is attracting the interest and stimulating the commitment of the cream of the crop of the scientific community.

Do I have a proper understanding of the problem?

Dr. BELL. I would say yes and no. It is clear there are bottlenecks in developing to a further state the excellent ideas that are already sort of on paper and being pursued on a small scale. Obviously, we can always use lots more good ideas. And I am sure that this is the sort of project that is going to attract attention from creative scientists from a large variety of disciplines, and there will be unexpected breakthroughs. I think that is one of the most exciting characteristics of it.

But at the present time it is clear we are resource- limited and we will always want to have new ideas.

Mr. SCHEUER. Right. Now, in recent years, we have seen modest increases in the DOE budget for nuclear medicine. Do you think that the current funding level enables the Department to fund enough new research proposals, or are promising avenues in research in nuclear medicine left largely unexplored due to budgetary constraints?

Dr. SETLOW. Let me just give you an example. And the answer is largely unexplored and there is a tremendous shortage of resources.

Mr. SCHEUER. Some promising areas of exploration are currently unexplored.

Dr. SETLOW. They are being explored very, very slowly. In that sense, they are unexplored.

The PET research that I was mentioning briefly at Brookhaven—that's the only one I know of, but I am sure it is typical of other areas—over the past seven years has increased in funding at the rate of approximately 2 percent per year. It's falling behind.

Mr. SCHEUER. That doesn't even begin to make up for the eroding effects of inflation.

Dr. SETLOW. Correct.

Mr. SCHEUER. In terms of constant dollars, your funding is being reduced every year.

Dr. SETLOW. Correct. So that's what I mean when I say there really isn't sufficient funding to carry out things that have immediate impact on human health, are interesting, and will revolutionize a lot of medical diagnostic and therapeutic procedures. The budget is too small.

In this particular area, from '89 to 90 I think the increase is 3 percent.

Mr. SCHEUER. Less than the cost of living increase.

Dr. SETLOW. Sure.

Mr. SCHEUER. Less than the cost of both services and programs and physical space, provision of the physical space.

Dr. Setlow, you said a little before that 10 percent of the research budget should go toward space, facilities, instrumentation.

Dr. SETLOW. Not space. Instrumentation and equipment; yes.

Mr. SCHEUER. Now, DOE has fallen far short of this figure over quite some years now; right? Do you think this has affected the entire field of nuclear medicine research and development? Is it a seriously constraining factor?

Dr. SETLOW. I think it's a serious constraining factor, not only in nuclear medicine, but in all other aspects of health research in the Department of Energy.

For example, in structural biology, attempts to determine structures of molecules, the whole program is severely constrained. We are asked to use state of the art instruments such as the light sources, without sufficient funds to put up the necessary instruments on these light sources. This is going to be a problem that Brookhaven has right now; it is going to be a problem for Berkeley; it is going to be a problem for the Argonne National Laboratory when their light source comes in.

Dr. MORSE. It is also a problem for our neutron source.

Dr. SETLOW. Also for the neutron source. We never have enough equipment. Five percent is an absurd number. Actually, it's closer to 4 percent.

Mr. SCHEUER. The 2 and 3 percent figures you gave me a moment ago are even more absurd.

Dr. SETLOW. Sure, they are. I mean these are the hands that feed me and they're not doing well enough.

Mr. SCHEUER. Well, you look well fed.

[Laughter.]

Dr. SETLOW. I speak for my colleagues that are not here.

Mr. SCHEUER. It may be that you don't have enough colleagues, enough promising young scientists who work with you and help develop these ideas.

Dr. SETLOW. That's a problem. The one that all my colleagues would say please emphasize is not enough funds for state of the art equipment.

Mr. SCHEUER. And for enough state of the art people, to attract them.

Dr. SETLOW. Well, it's a chicken and egg sort of thing.

Mr. SCHEUER. Dr. Shirley and Dr. Morse, what advantage do you feel your labs incur as a consequence of being designed genome centers by the Department? Is there any payoff?

Dr. SHIRLEY. Well, I'll respond to that. There is a payoff already. We have been able to attract an international leader as Director of our Center, Dr. Charles Cantor. I'm sure that being designated a Center had a major influence on Dr. Cantor's willingness to take on this challenging task.

Mr. SCHEUER. Maybe we ought to have him present to ask, once he took the job, what is the advantage to the work that he has undertaken and the mission and the responsibility of having it named a genome center.

Dr. SHIRLEY. Frankly, that is a concern to us. When he comes, he is going to need modern laboratory facilities. And as I indicated before, those seem to be very slow in coming. The budget has begun to increase. It's on a growth curve.

Mr. SCHEUER. How much of an increase percentage-wise are you going to be receiving from DOE in 1990?

Dr. SHIRLEY. Our operating budget will double from fiscal '89 to fiscal '90, from $2.5 to $5.0 million, so that is a dramatic percentage increase. That has a lot to do with Dr. Cantor's arrival in Berkeley. The number of full-time equivalent people will go up from 25 to 45, which is clearly a major percentage increase.

After that, we are expecting an increase to 54 FTEs in 1991 and 68 in 1992, and we hope that the project will grow to approximately 100 people steady state. So we're in a very critical stage in the growth of this project. You have to have of the order of 100 to exceed a threshold value that makes it viable.

Mr. SCHEUER. Dr. Morse, in your testimony on page 1, you referred to plant cells which are able to accumulate large amounts of plutonium, barium and other ground and water contaminants. Can you tell us how some of this research can be applied in the near future to help us clean up our national environmental mess, many of which exist at DOE facilities?

Dr. MORSE. That's kind of a fun story actually. If you don't mind, I'd like to tell it.

Mr. SCHEUER. By all means. It's been a tough morning so far. Let's hear a funny story.

Dr. MORSE. Jimsonweed is the material we are talking about. Folks in the West understand jimsonweed as being something you try to keep cattle and other animals away from. It tends to make them go bonkers. The reason it does that is because it sucks up selenium from the soil and the root structure, and selenium is a heavy metal.

Our fellow, Dr. Jackson, was working on the question of heavy metal toxicity. You might again wonder why it is that a National Laboratory is doing plant genetics, but there we were. And the part of the story that's kind of fun is the statement that Dr. Shirley and I have each referred to at the National Laboratories, the interdisciplinary character and the fact that people in the chemistry area, physics and so on, talk to one another.

In this particular case, people in our explosives manufacture became aware of the work that Jackson was doing and wondered if this same material would help them in wastestreams from some of the high explosive work, manufacture area.

And so they got together, because he was just handy, and checked and discovered yes, it does suck up barium just as well. And, furthermore, in the pink water that they were looking at, which is some of the residues—pink water means it's got trinitrotoluene in it as well as part of the high explosive work. Well, the pink water turned clear as well, so that these same cells absorbed in some fashion we're still working on, the trinitrotoluene as well as the barium in that work.

Jackson was about to go back to the Life Sciences Building and put this in an oven and dry it out when folks in the Dynamic Testing area suggested that might not be such a good idea.

Since then, clearly the potential for how this might work is interesting to us. The question is, can you develop root systems in these such that you could put those plants on mine tailings, and would it be a way of concentrating heavy metals in mine tailings up into a root system which you then might more readily take care of and locate?

One of the interesting things is that you don't have to have the plant. You can use the cells and grow these cells in culture and make sort of ion exchange columns out of them. We have run plutonium solutions through those columns, and in a single pass they will take out 95 percent of the plutonium. So we are very optimistic about that being a technology to be developed with industry to work within DOE and industrial sites because it appears to have a lot of potential.

Mr. SCHEUER. I have to be out of here in five minutes. I have a meeting in the Speaker's office.

Dr. Setlow, you gave us a very interesting presentation of some of the research that's being done on the effect of cocaine on the brain. Do you see the possibility ultimately of coming up with a cocaine antagonist, more or less equivalent to methadone which is a heroin antagonist, that would totally discourage people who are cocaine-addicted from staying on that drug? Is that one of the things?

Dr. SETLOW. I'm sure my colleagues, they are both in the chemistry department and the medical department, are thinking of that. And they have a way of checking whether this antagonist, if such is devised, will bind to the same receptors in the brain.

So the point of this research is to localize cocaine receptors and see if you can find an antagonist that will saturate those receptors.

Mr. SCHEUER. All right. The record is being held open—I got unanimous consent for that before—for 10 days or two weeks, and there may be some questions forthcoming from my colleagues on the committee.

Let me thank all four of you for a most stimulating, most thoughtful, most responsive hearing. We are very grateful. This hearing is adjourned, subject to the call of the Chair.

[Whereupon, at 12:01 p.m. the hearing was adjourned, subject to the call of the Chair.]

AUTHORIZATION HEARINGS FOR DOE ENVIRONMENTAL PROGRAMS IN FY 1990

THURSDAY, APRIL 27, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Natural Resources, Agriculture
Research and Environment,
Washington, D.C.

The subcommittee met, pursuant to call, at 1:07 p.m., in Room 2325, Rayburn House Office Building, Hon. James H. Scheuer (chairman of the subcommittee) presiding.

Mr. Scheuer. The Subcommittee on Natural Resources, Agriculture Research and Environment will come to order.

I am very happy that we have been joined by Sid Morrison, a very dedicated contributing member of our subcommittee.

Today we will consider the President's fiscal year 1990 budget request for the Department of Energy's Environment, Safety, and Health Program. This program was established in late 1985 in an effort to consolidate and improve the Department of Energy's management of activities in the area of worker health and safety and environmentally sound waste disposal practices. Since that time, the Department has undertaken a variety of studies aimed at determining the nature and extent of environmental problems in addition to evaluating the operational safety of its facilities.

While such studies are necessary to determine the Department's needs in these critical areas, there is a general consensus expressed by groups such as the National Resources Defense Council, and others, that more effort has gone into cataloguing the problem than into making actual improvements. In the light of this, I am strongly encouraged by the Secretary's promise to deliver by this August a comprehensive report containing a list of priorities for addressing clean-up activities at DOE sites nationwide.

I may say, I consider the Secretary of Energy one of the most outstandingly capable and competent and thoughtful members not only of this present Cabinet but of any Cabinet in recent memory. He is an extraordinarily talented human being, and I congratulate President Bush for appointing a man of his caliber, and this subcommittee and, I think, the Energy and Commerce Committee have high hopes for the Department of Energy under the leadership of the current Secretary, a man of astonishing—a wide and astonishing array of talents.

So the Secretary has promised to deliver a comprehensive report by August listing priorities for addressing clean-up activities at Department of Energy sites nationwide, and the report will lay out the Department's short-term plans to address these very significant environmental issues.

I'm further encouraged by the Secretary's appointment of Mr. Leo Duffy and his special assistant to coordinate defense waste programs and all other waste management, environmental response, and clean-up activities. I think these actions represent a new commitment on the part of the Department to resolve these difficult issues, and I congratulate you, Mr. Duffy, on your appointment, and I congratulate the Secretary for such a superb appointment.

Mr. DUFFY. Thank you.

Mr. SCHEUER. We will also hear later today from representatives of national laboratories which are actively engaged in developing new technical solutions to the awesomely complicated problem of hazardous waste management. The multi-disciplinary character and the special skills of these laboratories make them uniquely suited to undertake an increased role in developing these vitally important and much needed remedial technologies.

Certain environmental problems, such as the safe disposal of high level radioactive waste, are unique to DOE facilities, but the problems—but many of the problems associated with hazardous waste disposal are not. Research in waste disposal technologies will spur developments in the private sector as the technology is transferred and as the commercial potential of these technologies is developed and becomes more clear for private sector entrepreneurs.

[The prepared statement of Ms. Schneider follows:]

THE HONORABLE CLAUDINE SCHNEIDER
HEARING **STATEMENT**
DOE FY 1990 BUDGET FOR ENVIRONMENT, SAFETY, AND HEALTH PROGRAMS
APRIL 27, 1989

I WOULD LIKE TO START BY SAYING THAT I HAVE COMPLETE CONFIDENCE THAT THE NEW ADMINISTRATION WILL LIVE UP TO ITS COMMITMENT TO MAKE HEALTH AND SAFETY IN THE OPERATION OF DOE FACILITIES A TOP PRIORITY.

I BELIEVE THAT ADMIRAL WATKINS WAS AN OUTSTANDING CHOICE FOR SECRETARY OF DOE, AND I ALSO BELIEVE THAT HIS PROGRAM OFFICERS, SUCH AS PETER BRUSH AND LEO DUFFY, ARE MAKING AN EARNEST EFFORT TO CORRECT THE PROBLEMS OF THE PAST. AT THE SAME TIME, WE SHOULD NOT SUGAR-COAT THE CHALLENGE WE FACE.

THE HEALTH AND SAFETY RECORD AT DOE FACILITIES IS FRANKLY RATHER POOR.

- o OVERALL, ABOUT HALF OF DOE'S BUDGET WOULD GO TO DEFENSE PRODUCTION ACTIVITIES. YET INDEPENDENT REVIEWS BY A NUMBER OF ORGANIZATIONS INCLUDING THE NATIONAL ACADEMY OF SCIENCES AND THE GOVERNMENT ACCOUNTING OFFICE HAVE DOCUMENTED SERIOUS HEALTH AND SAFETY VIOLATIONS IN THE OPERATION OF THESE PLANTS.
- O THE POTENTIAL ENVIRONMENTAL THREAT FROM DOE FACILITIES IS ESPECIALLY TROUBLING. DOE HAS OVER 1,700 WASTE SITES THAT COULD BE ADDED TO THE SUPERFUND LIST.
- O FURTHERMORE, CLEAN UP OF THESE FACILITIES COULD BE MAJOR EXPENSE. ALTHOUGH COST ESTIMATES HAVE VARIED, SOME HAVE RUN AS HIGH AS $100 BILLION.

THE PROBLEMS OF THE PRESENT ARE ROOTED IN POLICIES OF THE PAST THAT WERE NOT SUFFICIENTLY FORWARD-LOOKING. AS PART OF ITS FUTURE CLEAN UP EFFORTS, DOE SHOULD CONCENTRATE MORE ATTENTION ON:

- O THE DEVELOPMENT OF INNOVATIVE CLEAN UP AND CONTROL METHODS; AND
- O THE IMPLEMENTATION OF A FORMAL POLICY TO REDUCE THE GENERATION OF WASTES AT THE SOURCE. I WOULD LIKE TO ELABORATE ON THIS SECOND POINT.

POLLUTION PREVENTION EFFORTS SHOULD BE STRENGTHENED

- O LAST YEAR, THE HOUSE APPROVED LANGUAGE CONTAINED IN THE SCIENCE COMMITTEE REPORT ON DOE THAT DIRECTED DOE TO PUT INTO PLACE A AN AGENCY-WIDE PLAN TO REDUCE THE GENERATION OF WASTES, AND TO REPORT TO CONGRESS.
- O WE ARE ENCOURAGED THAT DOE HAS MOVED FORWARD WITH SUCH A PLAN. ONE DOE DEPARTMENT ORDER ON THIS SUBJECT STATES THAT THE

MANAGEMENT OF RADIOACTIVE WASTES AND OTHER POLLUTANTS, QUOTE:

"SHALL BE ACCOMPLISHED IN MANNER THAT MINIMIZES THE GENERATION OF SUCH WASTES ACROSS PROGRAM OFFICE FUNCTIONS...." UNQUOTE.

- HOWEVER, MANY QUESTIONS REMAIN CONCERNING HOW DOE INTENDS TO IMPLEMENT THIS POLICY. THEREFORE, I AM LOOKING FORWARD TO SEEING THE REPORT TO CONGRESS THAT DOE IS PREPARING ON THIS SUBJECT, AND HOPE THAT IT WILL FORM THE BASIS FOR SOME REAL PROGRESS IN THE FUTURE.

MR. CHAIRMAN, THANK YOU FOR CONVENING HEARINGS ON THIS IMPORTANT SUBJECT.

Mr. SCHEUER. I would now like to recognize our distinguished minority colleague, Sid Morrison.

Mr. MORRISON. Thank you, Mr. Chairman.

I would indicate to you, sir, that one of the major reasons I asked for this subcommittee was, in fact, today's subject. It's vitally important for those of us that represent active Department of Energy facilities, and since we just celebrated the three-year anniversary of Chernobyl, I can say that my particular facility went first because it was characterized as being the most like Chernobyl, and that brought not only attention focused on safety issues but, I think, started a groundswell of movement on environmental restoration.

I think we have a unique opportunity. I concur with your very complimentary remarks about Secretary Watkins and am pleased that we have the potential, through the jurisdiction of this subcommittee, to make sure that we are making some very good buys and researching efficient processes for restoring the environment, coming up with new techniques so that we are doing that restoration, those repairs, in the most efficient possible manner.

So I look forward to the hearing, Mr. Chairman, and compliment you and your staff on the array of witnesses.

Mr. SCHEUER. Thank you very much, Sid.

Our first panel today here will be Mr. Leo Duffy, special assistant to the Secretary for coordination of DOE waste management; Peter Brush, acting assistant secretary for environment, safety, and health; and the two of them will be joined by Mr. Timothy Oppelt, director of EPA's Risk Reduction Engineering Laboratory.

Mr. Duffy, why don't you chat with us. Take five or six or seven minutes, and take note, as all of you might, that the full text of your prepared remarks will be printed in the record at this point. So you can simply liberate yourself from the printed page and chat with us informally.

STATEMENTS OF LEO P. DUFFY, SPECIAL ASSISTANT TO THE SECRETARY FOR COORDINATION OF DOE WASTE MANAGEMENT, U.S. DEPARTMENT OF ENERGY; PETER BRUSH, ACTING ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY, AND HEALTH, U.S. DEPARTMENT OF ENERGY, AND E. TIMOTHY OPPELT, DIRECTOR, RISK REDUCTION ENGINEERING LABORATORY, ENVIRONMENTAL PROTECTION AGENCY

Mr. DUFFY. Thank you, Mr. Chairman. Thank you for the kind words for both the Secretary and myself.

Mr. SCHEUER. We are very, very pleased by your appointment.

Mr. DUFFY. I hope I can live up to the expectations.

Mr. SCHEUER. I'm sure you will.

Mr. DUFFY. I think the main question that was asked is, how are we going to develop the five-year plan? and why are we—and looking at the five-year plan as a methodology to coordinate the environmental restoration areas.

When the Secretary came on board, he tried to get his arms around the situation, and at every presentation he made on his nomination, the first question that was asked was: "What are you doing about the waste management operation? What are you doing about the environment?" and he tried to put his finger on where was the emphasis being placed, and he couldn't do that readily.

So he asked me when I came on board to put together a five-year plan which would clearly identify what our priorities were, what we were doing with respect to allocating funds, how we were assessing priorities, what kind of confidence level did we have in the numbers that are in our data base, and, as you indicated, the environmental safety and health group put together a needs study which identified the number of contaminated sites we have throughout the DOE operation. And the question is always asked, "Well, do you believe those numbers from the standpoint they range from $30 billion to $150 billion?" I think the admiral said those were an envelope of what we felt was the estimate based on today's technology, and, as Congressman Morrison said, the key is to come up with better ways of doing it.

The methodologies that we are doing now—and I don't want to leave with the impression that we're just planning—there are quite a few evolutions going on at the present time to meet the priorities that the admiral identified.

The first priority was, any safety and health item became a first priority. Any compliance or out-of-compliance situation became a first priority. Those were our first priority operations. Environmental restoration was a second priority among peers, so that we would be confining and containing any contamination so it didn't spread further that gave us a larger problem in the out years.

Then we looked at what were our confidence levels in the dollars that were talked about, and that gets us into what we think is a major opportunity for us to come up with an R&D plan, and the R&D plan will identify how we can do the out years cheaper, because we're talking about a 20- to 50-year program if we're going to appropriate money for a $100 billion program, and at that point we have time to come up with technologies as long as you don't contaminate more of the environment while we're studying the problem.

So the key effort we're doing now is containment, confinement, and, where we can clean up, we will clean up, and, where we cannot clean up, we will identify the potential for risk and what we are doing to reduce the potential to the environment and to the public.

The other major item that the Secretary identified was, we have to get agreement from the people who are in the area where we have the contamination—the States, the local communities, the governors, and the attorney generals. So that's a prime area for the five-year plan.

We're working with the National Academy of Sciences in the technical area. We have identified a university to be a facilitator to get an outreach into the sociological and legislative areas for developing a plan, and what we hope to get is the comments from the public on how we're preparing the plan, whether or not they agree with our priorities, and whether or not they feel that the application of resources is fair and equitable. I think that's the key element that we expect to have for you by the August time frame.

Thank you, Mr. Chairman.

Mr. SCHEUER. Very good.

We've been joined by Congressman David Skaggs of Colorado.

David, do you have some opening remarks for us?

Mr. SKAGGS. No opening statement. Thank you, Mr. Chairman. I'll be anxious when we get into discussion with our witnesses.

Mr. SCHEUER. Very good.

Why don't we hear from you then, Mr. Brush.

Mr. BRUSH. Thank you, Mr. Chairman.

Mr. SCHEUER. The acting assistant secretary for environment, safety, and health, of the Department of Energy, Peter Brush.

Mr. BRUSH. That's right. Thank you very much.

We in the Office of Environment, Safety, and Health are delighted with the initiatives that the Secretary has taken. We're working very closely with Mr. Duffy and his staff. Our expertise in the area of overseeing compliance by the Department and its contractors with relevant environmental laws and requirements is something that we're just absolutely delighted has been elevated to the secretarial Cabinet level, and it's about time this has been done, and we're looking forward to working closely with that.

I'd like to mention just briefly while I have a moment the program—other programs of the Office of Environment, Safety, and Health, summarize them very briefly, put them out on the table for you.

It's already been mentioned that during this past fiscal year we completed a number of important studies, base line studies used in this area, one of them being the environmental survey. In fiscal 1990, we're going to move ahead to turn that into a program of environmental audits to ensure continuing compliance by the Department with applicable environmental laws. We're also focusing on our compliance activities under the National Environmental Policy Act.

The Department has a large number of big projects coming along that are going to require adequate and complete compliance with the National Environmental Policy Act, and our office's responsibilities are to ensure that we execute those responsibilities in a timely and in an effective means.

We're also intimately involved, Mr. Chairman, in the area of global climate change, and particularly we're conducting four major studies directed by the Congress in those areas. One is an assessment of Federal Government alternative energy R&D programs in terms of their potential to reduce greenhouse emission, gas emission. Another is an analysis of policies that could achieve 20 and then 50 percent reductions in greenhouse gas emissions by the end of the century. We're assessing U.S. Government policies in this area to develop trends in the greenhouse gas emission area; and, finally, we are doing an analysis of Federal policies to encourage private sector activities in the area of climate change.

Mr. Chairman, my office also is responsible for the oversight of the Department's nuclear safety activities, an area that's going to be particularly important in the coming months. It's been clear to us that a more intensive safety oversight program is needed in the Department, and we are pursuing major efforts, as indicated in my opening statement for the record, which will improve the level of safety assurance afforded at both our nuclear and non-nuclear facilities, including internal and external oversight measures consistent with the recommendations of the National Academy of Sciences.

We have reorganized the offices, the safety offices, in the EH—Office of Environment, Safety, and Health, and we have established in particular—and I know this is something that's been of interest to the committee—a program of on-site headquarters EH representatives in the field. This follows, in particular, a recommendation by the National Academy of Sciences that our office have a permanent and significant on-site presence.

Other major safety initiatives that we are conducting and will continue are multi-disciplinary safety inspections of all of our facilities, improved safety standards and guidance to ensure that our facilities are more clearly defined and comparable to generally accepted safety practices for nuclear operations, we're conducting improved safety analyses, we've established a contractor self-improvement program to foster excellence across the Department's facilities, and we're installing an improved training program for our nuclear facility operator.

Therefore, Mr. Chairman, our fiscal 1990 budget request is just over $124 million, an increase of $33 million, and my prepared statement will give the details and comprehensive tables explaining this request.

Thank you very much.

[The prepared statement of Mr. Brush follows:]

Statement of

Peter N. Brush

Acting Assistant Secretary
Environment, Safety and Health
U.S. Department of Energy

Before the

Subcommittee on Natural Resources,
Agriculture Research and Environment

of the

House Science, Space and Technology Committee

April 27, 1989

Mr. Chairman and members of the Subcommittee, I am pleased to be here today to discuss with you the Department of Energy's (DOE) FY 1990 budget request for the Office of Environment, Safety and Health (EH).

The Department's mission to meet national energy and security objectives carries with it a fundamental responsibility to assure that the mission is accomplished while not only achieving an acceptable level of environment, safety and health practices, but pursuing environment, safety and health excellence. The Department is firmly committed to operating its facilities safely and to expediting the cleanup of our nuclear weapons facilities. President Bush's budget plans fully reflect this commitment.

The Department of Energy nuclear weapons complex is one of the largest industrial operations in the United States dealing with hazardous materials. Early waste management practices have proved inadequate for long-term environmental protection and left this country with a serious problem. The President has stated that he is committee to cleaning up these sites, and he personally directed the Secretary to move forward expeditiously with an aggressive cleanup program.

Accordingly, one of the highest priorities of Secretary Watkins is to strengthen the Department's nuclear waste management activities, including environmental compliance and cleanup. Secretary Watkins has directed the preparation of an integrated Five-Year Plan that establishes priorities based on risk to public health. This comprehensive plan will encompass defense waste management operations, inactive waste site cleanup, and corrective actions needed for all DOE operating facilities. I am attaching for the record a copy of the letter the Secretary sent to you, Mr. Chairman, which more fully sets out this initiative. As noted in the letter, this activity is being coordinated by Mr. Leo Duffy, Special Assistant to the Secretary for Coordination of DOE Waste Management, and the Office of Environment, Safety and Health is an active participant in it.

A responsive and realistic approach to solving the Department's environmental problem requires a coordinated approach which deals with problems as a whole. The Five-Year Plan will be developed from data and information submitted by each DOE Operations Office and will consolidate all DOE cleanup activities into a single, integrated action plan. Priority attention will first be given to corrective actions that will ensure DOE's compliance with all applicable Federal and State requirements. The highest priorities will be placed on facilities where contamination has occurred that may potentially affect public health and the environment. Consistent with the President's directive to ensure environmental compliance at the Department's facilities, the views and concerns of all other Federal agencies as well as affected States and Indian Nations will be addressed to ensure that our priorities are viewed by these entities as being fair, timely and effective. When finalized it will be sent to the Congress.

The plan will also be used to reaffirm FY 1990 activities as well as to serve as a baseline for FY 1991 programs and budget requests. The President's FY 1990 budget request would allow the Department to proceed with needed environmental investigations and studies. Commencing in FY 1991, the Department expects to request funding for a number of projects as site investigations are completed and informed decisions can be made.

The Secretary has also announced plans to establish a similar program in applied research and development, with emphasis on the advancement of environmental remediation technology. The National Academy of Sciences has agreed to participate in this effort, designed to put DOE's program on the cutting edge of technology development.

At the same time that DOE is developing detailed plans on how it proposes to approach ongoing and future cleanup activities, significant progress in being made throughout DOE facilities in achieving compliance with today's stringent RCRA requirements. Secretary Watkins intends to report to Congress annually on the progress being made to correct all outstanding compliance issues.

Planned FY 1989 Accomplishments

Since the establishment of the Office of Environment, Safety and Health in 1985, the Department has undergone a significant transition in its approach to implementing and overseeing safe and environmentally sound operations. The primary role of the Office of Environment, Safety and Health is to provide Department-wide oversight to ensure program emphasis on environment, safety and health. In FY 1989, the Environment, Safety and Health program is giving top priority to continued strengthening of internal oversight systems.

With the completion of the Environmental Survey in FY 1989, a program of environmental audits is being implemented to ensure continuing compliance with applicable environmental requirements. Efforts will continue to work with EPA and involved states to address environmental problems at all DOE defense production sites. Further, in FY 1989, we are also beginning a program of NEPA compliance appraisals to ensure that NEPA responsibilities are properly executed and as a means of providing NEPA technical assistance. This is an area of growing importance due to a number of high priority new projects such as New Production Reactor Capacity, Super Conducting Super Collider, the Clean Coal Technology projects, and those projects which will be necessary to deal with the aging DOE defense complex.

In the area of global climate change, four studies directed by Congress are underway. These studies include:

- an assessment of Federal Government alternative energy R&D programs in terms of their potential to reduce greenhouse gas emissions;
- an analysis of policies to achieve 20 percent and 50 percent reductions in greenhouse gas emissions;
- an assessment of U.S. Government greenhouse gas emissions and climate change trends data coordination and accessibility; and

- an analysis of Federal Government policies to encourage the private sector to address climate change through adaptive, mitigative and preventive actions.

We expect to complete these four studies in 1989.

Although substantial gains have been made in strengthening safety oversight within DOE, it is clear that a more intensive safety oversight program is necessary given the number and hazardous nature of DOE's diverse facilities. In FY 1989, major efforts are being pursued to further improve the level of safety assurance afforded at nuclear and non-nuclear facilities, including both internal and external oversight measures, consistent with the recommendations of the National Academy of Sciences (NAS) reports. The NAS concluded that the functions embodied in the then existing EH safety organization were not comparable in quality to those utilized to assure the safety oversight of commercial nuclear facilities. To correct this, the EH safety offices have been reorganized and now include those roles, functions, and responsibilities that have been demonstrated over time to constitute effective safety oversight for commercial nuclear facilities. The reorganization includes establishment of an on-site Headquarters EH presence in the field, and follows a recommendation by NAS that EH should have a permanent and significant on-site presence. This initiative, begun in FY 1988, will be fully implemented in FY 1990.

Other major safety initiatives being pursued in FY 1989 and continuing in FY 1990 include:

- o more frequent and comprehensive multidisciplinary safety inspections and appraisals of nuclear and non-nuclear facilities;
- o improved safety standards and guidance to assure that DOE safety requirements are more clearly defined, uniform, and comparable with generally accepted safety practices for nuclear and non-nuclear operations;
- o improved safety analyses, including special technical evaluations and reviews of safety concerns at existing facilities;
- o the establishment of a contractor self-improvement program to foster excellence and to complement the Department's agreement with the Institute for Nuclear Power Operations; and
- o improved training programs for nuclear facility operators.

In addition, aggressive efforts to recruit additional well-trained, experienced and technically competent personnel are continuing. One of the concerns identified by the National Academy of Sciences was that the Department has relied almost entirely on its contractors to identify ES&H issues and to recommend corrective actions. The present strategy is to continue our recruitment efforts and in the meantime to bolster in-house staff with specialized contract support.

FY 1990 Funding

The FY 1990 budget request for the Environment, Safety and Health program is $124 million, an increase of $33 million above the FY 1989 appropriation of $91 million. The increased funding is needed to continue efforts begun three years ago to strengthen the Department's environment, safety and health oversight program. The following is a summary of our FY 1990 budget request:

Environment, Safety and Health
($ in thousands)

Activity	FY 1989 Approp.	FY 1990 Request	Difference
Environmental Audit	$17,000	$17,000	$0
Environmental Guid & Comp.	4,300	7,400	+3,100
NEPA Project Assistance	2,900	4,000	+1,100
Environmental Analysis	6,000	4,300	-1,700
Medical Director	700	900	+200
Safety Appraisals	12,250	19,250	+7,000
Safety Compliance	2,100	3,450	+1,350
Quality Programs	6,000	8,000	+2,000
Safety Pol & Standards	18,850	23,050	+4,200
Facility Opr. Training and Asst. Prog.	--	10,000	+10,000
Advisory Committee on Nuclear Fac. Safety	3,000	3,000	0
Planning & Info. Res. Management	3,190	4,000	+810
Program Direction	11,400	17,176	+5,776
Capital Equipment	3,100	3,100	0
Use of Unobligated Balances and Other Adjustments	+210	--	-210
Total	$91,000	$124,626	+$33,626

FY 1990 Overview

Environmental Audit ($17 million): The goal of the Environmental Audit Program is to provide comprehensive oversight of the Department's operating facilities to ensure compliance with all applicable environmental requirements and to reduce areas of existing or potential environmental risk. In FY 1989, the baseline Environmental Survey will be completed. In addition, a new environmental audit program will be initiated, with 10 audits to be completed in FY 1989 and 24 comprehensive audits per year in FY 1990 and thereafter. These audits will focus on regulatory compliance, will evaluate the effectiveness of existing environmental management systems, and will include rigorous reviews of site environmental sampling and monitoring programs. Funds requested will also provide for 10 special, focused audits limited to particular areas of environmental concern or environmental regulation.

Environmental Guidance and Compliance ($7.4 million): The Environmental Guidance and Compliance function provides environmental policy and technical guidance to DOE operations for implementation of applicable requirements, and provides oversight and coordination of compliance activities. Demands on this program are increasing in consequence of the passage of the Superfund Amendments and Reauthorization Act and the growing number of environmental issues that must be coordinated in light of EPA and State efforts to obtain compliance at DOE and other Federal facilities. For FY 1990, specific goals of the Environmental Guidance and Compliance program include continuing efforts to ensure compliance with the Resource Conservation and Recovery Act requirements for all radioactive mixed waste facilities at DOE sites; to assist the Department in its Comprehensive Environmental Response, Compensation, and Liability Act program into the remedial investigation/feasibility study and remedial action phases; and to analyze future environmental requirements applicable to DOE operations. To meet the greater demand on this program, a $3.1 million increase is requested for FY 1990.

NEPA Project Assistance ($4 million): The NEPA Project Assistance program performs ongoing National Environmental Policy Act (NEPA) functions including project review and technical assistance. The workload of the NEPA Project Assistance program is determined by the demands of DOE program offices for NEPA support and oversight services, and includes new projects and facilities as well as modifications to existing facilities. Program areas include Defense Programs (e.g., new facilities such as the New Production Reactor project, modifications to existing facilities, and waste management facilities); Nuclear Energy (e.g., new reactor technologies, uranium mill tailings remedial actions, and cleanup of surplus facilities and formerly-utilized sites); Fossil Energy (e.g., the clean coal technology program, other innovative technologies, petroleum reserves development, and asset divestiture); power marketing policy and transmission line projects; Energy Research (e.g., high energy physics, magnetic fusion, and particle accelerators); regulatory projects, conservation and renewable energy projects, and international activities.

In FY 1990, an increase of $1.1 million is requested for this program for support to major ongoing and highly complex projects, including the Defense Programs modernization efforts. NEPA requirements for the modernization effort will likely include NEPA documentation for new facilities construction projects, decontamination and decommissioning projects, and various waste management and disposal projects. In addition, a program of NEPA appraisals will be initiated to foster adequate, timely and consistent compliance with NEPA.

Environmental Analysis ($4.3 million): The Environmental Analysis program provides responsive analyses and options development with respect to significant environmental issues that affect national energy supply, demand and prices. This is accomplished by the analysis and coordination of energy-related environmental issues to assure the full development and assessment of policy options in DOE decisions affecting U.S. energy systems and in development of associated policies and programs. In FY 1990, the program will continue to evaluate the energy industries' impact on the environment, emphasizing air quality (including ozone depletion) and waste disposal. Also, analytical support will be provided to interagency acid rain research activities needed to develop the National Acid Precipitation Assessment Program final report. The $1.7 million reduction for this program is a result of completion in FY 1989 of the 4 global issues studies directed by Congress.

Medical Director ($900 thousand): The Medical Director has Departmental responsibility for providing occupational medicine program oversight for all DOE government-owned contractor-operated facilities and assuring that DOE contractor employees at these facilities are provided medical care within Department standards. The Department has the largest occupational medicine program in the world, comprised of 48 contractor occupational medical departments located at DOE facilities, and employing 120 occupational physicians and some 2,000 ancillary occupational health specialists. During FY 1990, this program will focus on increasing the frequency of onsite reviews of field office and contractor medical programs, and will continue to support the Department's personnel reliability programs including the Drug Free Workplace Program. An increase of $200 thousand is requested in FY 1990 to support this program.

Safety Appraisals ($19.25 million): The Safety Appraisals program provides independent oversight of all DOE-owned, contractor-operated nuclear facilities by evaluating the overall safety performance of the field organizations and operations at high-hazard and select moderate-hazard nuclear facilities. The FY 1990 requested increase of $7 million will support more frequent and comprehensive safety appraisals, as required by the Department's aged nuclear facilities, many of which do not contain contemporary safety features. Starting in FY 1990, multidisciplinary team safety appraisals of the Department's 8 Category A reactors, 14 Category B reactors, and 9 of the 22 high hazard nonreactor facilities will be conducted annually. Followup activities to ensure that deficiencies found in these and previous appraisals have been corrected are included in this program. Design reviews will also be performed of all Category A reactors to determine the adequacy of the design of the reactors relative to expected margins of safety. Increased funds will also support efforts to improve the overall quality of safety analysis reviews and pre-operational evaluations to ensure that all safety issues have been resolved prior to a facility startup.

Safety Compliance ($3.45 million): The mission of the Safety Compliance program is to monitor corrective action programs developed in response to deficiencies identified by EH safety appraisals and to provide an overall diagnostic assessment of safety program performance at DOE facilities and operations. The requested increase of $1.35 million in FY 1990 will support the development of performance measurement criteria and performance indicators; methods for diagnosing root causes; and trend analysis to identify potential safety problems so they can be corrected before they deteriorate.

Quality Programs ($8 million): The focal point for quality assurance, non-nuclear safety expertise, and daily onsite monitoring (resident engineers) of safety in the Department is Quality Programs. Areas of safety that are within the primary purview of Quality Programs include fire protection, industrial hygiene, explosive safety, transportation safety, firearms safety and dam safety. We are requesting an increase of $2 million in FY 1990 for Quality Programs.

In FY 1990, activities will continue to be enhanced to meet the overall goal to strengthen safety oversight. The program of safety appraisals of important Department non-nuclear facilities, begun in FY 1989, will be expanded to accomplish comprehensive annual safety appraisals of all high hazard and one-third of the moderate-hazard non-nuclear facilities. The program will expand its capability to perform special diagnostic appraisals that are focused specifically in response to QA deficiencies identified during multidisciplinary team appraisals, Environmental Surveys, data analyses and other EH oversight activities. Emphasis will be placed on determining the root causes of problems or failures, and related quality verification deficiencies.

In addition to the activities described above, Quality Programs is also responsible for the onsite resident program. This initiative follows a National Academy of Sciences recommendation that the Office of Environment, Safety and Health should have a permanent and significant on-site presence. Residents on-site are responsible for making technical observations to assure that issues and problems are promptly brought to DOE management's attention for resolution. An on-site presence has been established at Rocky Flats, and Savannah River, with plans to staff additional key sites during FY 1989 and FY 1990.

Safety Policy and Standards ($23.05 million): The overall mission of Safety Policy and Standards (OSPS) is to assure the adequacy and the timely issuance of DOE safety policies and standards through a coherent, comprehensive, and consistent approach to the development and implementation of the Department's safety policy. OSPS is the central point for coordination within DOE and for liaison with other agencies and groups in the development of safety, health and quality assurance related regulations, standards, and requirements. It coordinates resolution of issues applicable to DOE operations, including review of proposed statutes, regulations, standards, and requirements for their application to and potential impact on DOE activities. OSPS also provides functional safety programs in emergency preparedness, health physics, risk assessment, and training.

The currency and soundness of the Department's safety requirements are essential. The types of operations conducted by the Department are not risk free. However, through the development of safety objectives, safety policies and safety standards, we are providing a framework for managers and decisionmakers that will assure a minimal level of risk to the public and workers in design, operations, and under accident conditions. The Safety Policy and Standards program was established in response to the need for a focused organizational function in safety policy development, a regulatory role served by the Nuclear Regulatory Commission for the commercial nuclear industry. Consistent with recommendations of the National Academy of Sciences, the scope and content of DOE safety orders, standards, and guidelines are being evaluated and revised as necessary to assure their adequacy.

The $4.2 million increase requested in FY 1990 will support the ongoing process of identifying safety policy gaps, inadequacies, and issues; evaluating available options; and developing directives and standards, providing guidelines for implementation, and monitoring their effectiveness in application. The continuing review of NRC regulations and industry nuclear safety standards are a fundamental part of this process. In addition to prescribing acceptable safety performance, policies are being developed for safety review and decision making, including performance of safety analyses, nuclear facility backfit, and notification and reporting. Guidance on the conduct and application of probabilistic risk assessments to nuclear facility operations is an essential feature of the risk-based approach to safety performance being engendered in DOE safety policy, appraisals, and operations.

Facility Operator Training and Assistance Program ($10 million): The Facility Operator Training and Assistance program is a new initiative for FY 1990. It has been the consensus of both external safety reviews of

DOE operations and internal EH safety appraisals that a more consistent, interactive, and vigorous DOE program of operator training, accreditation and procedures development is needed. Given the diverse nature of operations within the DOE complex, a comprehensive approach must encompass both facility-specific as well as DOE-wide implementation of accepted practices and accreditation programs, and exchange of operating experience.

The Facility Operator Training and Assistance Program is designed to provide this capability to address fundamental training for operators, maintenance personnel, and technical support personnel. As implemented through a DOE-administrated contractor self-improvement program (DOE's version of the commercial nuclear industry's Institute for Nuclear Power Operations), the Facility Operator Training and Assistance Program will also provide an interface with the Nuclear Regulatory Commission, the Institute for Nuclear Power Operations, and the commercial industry thereby providing a mechanism by which commercial industry practice and experience can be disseminated throughout DOE operations. The FY 1990 request for this activity is $10 million.

Advisory Committee on Nuclear Facility Safety ($3 million): The Advisory Committee on Nuclear Facility Safety was established in FY 1988 as recommended by NAS. It is an independent, external oversight committee for nuclear safety and reports directly to the Secretary. The Committee is comprised of recognized experts from outside DOE, appointed by the Secretary of Energy under the Federal Advisory Committee Act. The Committee provides technical advice to assist the Secretary in carrying out his statutory responsibility for safe operation of DOE facilities. The Committee has broad authority to review Departmental activities at the production reactors, including design review, safety analyses, operations, management, inspection and enforcement.

During FY 1990, the Committee, supported by its DOE staff, will continue to review the safety of DOE facilities using consultants and sponsoring the conduct of studies by contractors. Recommendations for improvements to DOE's operations will be provided to the Secretary of Energy as investigations are completed.

Planning and Information Resources Management ($4 million): Commensurate with the expansion and broadening of its environment, safety and health oversight responsibilities, is a dramatic growth in the quantity of information that the Office of Environment, Safety and Health must gather and maintain for analysis and recordkeeping purposes. Sources of the information include, but are not limited to: standards and codes; regulations; appraisal, audit, survey, assessment and inspection findings; corrective action plans and status; reports of unusual events and occurrences; operational and performance data; safety profiles for each operating facility; results of investigations and analyses; and ES&H directives. Computer managed systems will continue to be operated and maintained to collect, store and track the information. In FY 1990, centralization of the management and administration of the information system will be completed and will greatly improve the efficiency of our information systems.

Program Direction ($17.2 million): The Program Direction account provides funds for salaries, benefits, and travel for the staff complement of the Office of Environment, Safety and Health, as well as funds for support contracts that furnish centralized administrative and technical services to the full range of Office functions. An increase of $5.8 million is requested in FY 1990 to support an increase of 61 FTEs over FY 1989, for a FY 1990 total staffing level of 276 FTE's.

Additional Federal staff are needed to support the expanded environmental and safety program responsibilities as described above.

Capital Equipment ($3.1 million): Capital equipment funds are requested to support the extensive operational capabilities of the emergency response systems including the Aerial Measurement System and the Atmospheric Release Advisory Capability; to purchase laboratory equipment in support of our health physics radiation exposure research efforts; and for additional computer storage equipment in support of information systems.

This concludes my prepared statement. I would be pleased to answer any questions from the Committee.

Mr. SCHEUER. Thank you very much, Mr. Brush.

Mr. Oppelt.

Mr. OPPELT. Thank you, Mr. Chairman.

I would briefly like to summarize some of the cooperative and coordinating efforts that EPA has had with the Department of Energy in the area of radioactive site and hazardous waste site clean-up. Particularly, I'd also like to discuss some of the EPA research activities in radioactive site waste clean-up and also describe some recent cooperative efforts we've had with the Department of Energy in this area.

I'm only going to discuss the research activities and development activities. If you have questions relating to the process of the Superfund activities or any of the specific details of our involvement with the Federal facilities, Christopher Grunler, the director of our Federal Facilities Hazardous Waste Compliance Office, is with me here today, and he would be able to answer those.

The main source of our cooperation with the Department of Energy and as well as the Department of Defense over the past eight to nine years has been an interagency work group on hazardous waste technologies. We meet once a year and share information on technologies that we're evaluating, discuss ongoing projects, and look for opportunities for cooperative efforts, and we put out an annual report that summarizes all this work, and I've basically found this to be a very effective and beneficial cooperative relationship. A number of cooperative projects have resulted from this interaction over the years.

Our activities in the area of radiologically contaminated Superfund sites has centered around two recent studies that we have conducted. The first of these resulted in a report that was published in August of 1988 entitled "Technical Approaches to the Clean-up of Radiologically Contaminated Superfund Sites" and was followed on by a further study entitled "Interim Draft Report and Assessment of Technologies for the Remediation of Radioactively Contaminated Superfund Sites." This came out in December of 1988.

The objectives of these two studies were to identify the Superfund radiation sites that were out there, categorize these according to the type of contamination and the matrix which that contamination was in, to identify and describe, as best we could, possible technologies for remediating those sites, and then, finally, to rank these technologies by their ability to perform on those waste matrices, their applicability to those wastes and waste matrices, and by the stated development of those technologies, and then, finally, the reports made recommendations for research, development, and demonstration.

The general findings of the studies, just to summarize them briefly, were that there were 25 radiologically contaminated sites on the national priorities list, or proposed for the priorities list, six of which were DOE facilities. The most frequent contaminant at these sites, 23 of the 25 sites contained this, were soils contaminated with radium, uranium, and thorium. The second most prevalent problems were water contaminated with those same materials; and then, finally, soils mixed with mixed radioactive and hazardous waste.

Twenty-nine clean-up technologies were identified, including on-site and off-site techniques, techniques for immobilization, concentration, and volume reduction, and we also looked at what kinds of remedies had been applied to date. These were largely on-site containment or removal to off-site storage and containment. So none of the technologies we really were looking at in terms of advanced technologies have really been applied yet in the field.

The technologies identified, I should point out, don't destroy the radiation, they just simply concentrate it, so we still are going to have to worry about a material that is going to require some secure long-term disposal.

Ten technologies showed a high potential particularly for soils treatment, which we saw as one of the most pervasive issues. Those were areas of separation technology, extraction technology, and immobilization technology, and the specific processes are listed in these reports.

As I pointed out, these processes are adapted in many cases from our other Superfund clean-up activities and from the processing of ores and have only really been tested in terms of contaminated site clean-up at the bench or pilot scale, not in actual field situations.

We are now moving towards the demonstration of some of these technologies through our Superfund Innovative Technology Evaluation program, or the SITE program that EPA has. The purpose of the SITE program is to promote the use and development of more cost-effective and permanent technologies for remediation of Superfund sites and was authorized under SARA in 1986 and provides an ability for EPA to enter into cooperative demonstrations with private developers to demonstrate these technologies. We have completed 10 demonstrations to date and have 18 more scheduled in the next 18 months. There was also a report to Congress which was just sent to Congress this week summarizing the results of our progress up through fiscal '88.

Two of these demos are specifically looking at radioactive waste technologies. The first of these is a thermal treatment centrifugal reactor developed by Retech, Incorporated, which is a process that uses a high-temperature plasma arc to basically destroy organics in the waste and then melt the remaining inorganics and the radionucleides into a glass type waste. This is being demonstrated—to be demonstrated, I should say, at a DOE facility in Butte, Montana, some time this summer, and it will be demonstrated not on the radioactive wastes but a waste very similar to that.

Another technology we're looking at is the process called in situ vitrification. This is a process that was developed by DOE's Pacific Northwest Labs and is currently being licensed by a company called Geosafe, Incorporated. The process involves decontam—not decontaminating—basically heating to high temperatures the waste materials in situ and placed in the ground with electrodes and creating a vitrified mass that, hopefully, will be not susceptible to leaching.

We're also looking to other cooperative projects to demonstrate radioactive waste treatment techniques through a cooperative agreement with the State of New Jersey. We've signed this cooperative agreement to basically go out and solicit venders of technologies to come in and actually demonstrate these new technologies on contaminated soil sites in the State, and we're working with them to identify through a solicitation who would do that.

Finally, EPA's Office of Radiation Programs has also been conducting studies on a smaller scale of some of the promising technologies that we identified, including physical separation, soil washing, chemical extraction, and magnetic separation, and we're looking forward to the results of those studies which are showing great promise right now.

In summary, we believe that further collaboration with DOE would facilitate the application of these technologies at Federal sites, and we're looking to continuing our good relationship with DOE.

Thank you very much.

[The prepared statement of Mr. Oppelt follows:]

TESTIMONY OF
MR. E. TIMOTHY OPPELT
DIRECTOR
RISK REDUCTION ENGINEERING LABORATORY
U.S. ENVIRONMENTAL PROTECTION AGENCY
CINCINNATI, OHIO
BEFORE THE
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH,
AND ENVIRONMENTAL
OF THE COMMITTEE ON SCIENCE AND TECHNOLOGY
U.S. HOUSE OF REPRESENTATIVES

APRIL 27, 1989

Good morning, I am E. Timothy Oppelt, Director of EPA's Risk Reduction Engineering Laboratory in Cincinnati, Ohio. I would like to briefly describe for you this morning some of the coordination we maintain with the Department of Energy (DOE) on hazardous waste cleanup technologies generally, some of the EPA research and demonstration activities related to radioactive waste, and recent efforts to work jointly with DOE on this subject. I will confine my remarks to research, development and demonstration (RD&D) of cleanup technologies. We have others here from EPA who can answer questions about the management of the Superfund cleanup process and cleanup of Federal facilities.

EPA uses a wide range of cleanup technologies for remediation of hazardous waste sites. However, EPA is actively seeking and promoting the development and use of more cost effective and permanent cleanup technologies. One major program is the Superfund Innovative Technology Evaluation (SITE) Program. This program was mandated by the Superfund Amendments and Reauthorization Act of

1986 to encourage development and use of innovative technologies at Superfund sites through cooperative demonstrations between technology developers and EPA. The SITE program is now in its third year and has resulted in 10 field demonstrations to date with 18 others anticipated over the next eighteen months. EPA anticipates issuing shortly its second Report to Congress covering the program's progress and accomplishments through 1988.

We are encouraged by the private sector's response to the SITE program and its willingness to develop more cost effective cleanup technologies. We think some of these new technologies will prove to be valuable additions to our arsenal of Superfund cleanup weapons.

Since 1980, EPA and the Department of Defense (DOD) have been meeting formally in an Interagency Work Group on Hazardous Waste Technologies. In 1986 this Work Group was expanded to include the Department of Energy. The most recent Work Group meeting was in June 1988. The purpose of the Work Group is to share information, discuss ongoing hazardous waste RD&D projects, and identify areas for cooperative research.

In December 1986 the group published its second Report of DOD/EPA/DOE Working Group to Explore Hazardous Waste Technology Cooperative Efforts. The third edition of this document, which is based on the June 1988 meeting, has just gone to press. Projects listed are subject to ongoing discussions at these meetings. As a result of this Work Group, EPA, DOD, and DOE have developed a number of co-funded projects. EPA and DOE have also co-funded the incorporation of an EPA incineration database into a DOE hazardous waste database maintained at the Oak Ridge National Laboratories (ORNL).

Turning now to radioactive waste, in August 1988 EPA published a report on Technical Approaches to the Cleanup of Radiologically Contaminated Superfund Sites. This report was the result of a Congressional request to see what technologies might be available for eventual use to remediate Superfund radiation sites. In this report we attempted to do three things. First, identify the Superfund radiation sites; second, systematically review the full range of possible cleanup technologies for contaminated soils; and third, briefly describe some of the relevant DOE cleanup programs.

At the time the report was prepared, there were twenty proposed or listed National Priorities List (NPL) sites containing radioactive wastes. There are currently twenty-five sites of which six are DOE facilities. The sites involve a wide range of contaminated media, types of toxic and radioactive waste, and size (less than 50 cubic yards to over 16 million cubic yard~~s~~).

The August report reviewed the state of the art of the following types of remediation technologies: on-site disposal, off-site disposal, on-site treatment, radon control, chemical extraction, physical separation, and combined physical separation and chemical extraction. This review had input from EPA's Office of Emergency and Remedial Response(Superfund), EPA's Office of

Radiation Programs, all 10 EPA Regional Offices, as well as the Department of Energy.

Based on this review, a number of conclusions were reached. The following are some of the conclusions regarding technological approaches.

-- Alteration or remediation of the radioactive decay process, thus changing the fundamental radioactive hazard, is not possible.

-- Remediation, to date, has involved only removing contaminated material and containing it in above-ground land encapsulation, drums, or temporary storage sites.

-- Alternative treatment technologies that may warrant further study include solidification, vitrification, chemical extraction, physical separation, and combinations of physical separation and chemical extraction. However, even for these treatment technologies some form of containment or disposal of radioactive residual would always be needed.

-- Various remediation technologies may have the potential to reduce the volume of contaminated waste with an associated increase in the concentration of the radioactive material.

-- Remediation technologies generally result in the disturbance of contaminated material. This often involves risk to human health and the environment which must be weighed against leaving the contaminated materials on-site in a contained state.

The DOE programs summarized in the report include the Formerly Utilized Sites Remedial Action Project (FUSRAP), Surplus Facilities Management Program (SFMP), Uranium Mill Tailings Remedial Action Project (UMTRAP) and Grand Junction Remedial Action Project.

In December 1988 EPA published the interim final draft of an Assessment of Technologies for the Remediation of Radioactively Contaminated Superfund Sites. The final draft of this report will be published in June 1989. The December report categorized the 25 NPL radiation sites and their problems, developed criteria for rating technologies, identified promising technologies based on those ratings, and made recommendations for research, development and demonstration. We are currently gathering additional documentation for the final draft of the report.

The December report categorizes Superfund radiation sites according to the nature of the contaminated materials at the site (soils, water and/or structures) and of the contaminants (radium, thorium and/or uranium; other radionuclides -- e.g, plutonium; and mixed radioactive and hazardous waste). So, for example, of the 25 sites, 23 have soil contaminated with radium, thorium and/or uranium; 20 have water contaminated with these elements, 11 have soils contaminated with mixed waste, and many of the sites have multiple problems.

Two sets of criteria were developed to rate new cleanup technologies. These criteria are based on the mandates and preferences under the Superfund law. First, there are two performance criteria. One rates the long-term reliability of the treatment process. The other rates the effectiveness of the technology in reducing the toxicity, mobility, or volume of the waste. There are also two developmental criteria. One rates the stage of research and development; the other rates the available information on the state of development.

Promising technologies were defined as having the highest performance scores for application with each type of contaminated material and contaminant group. For example, there are 11 promising technologies for cleanup of soils contaminated with radium, thorium and/or uranium, but only one promising technology for cleanup of water contaminated with mixed waste.

These two reports have given EPA a good basis for deciding on priorities for research, development, and demonstrations of radiation cleanup technologies.

We are now moving toward demonstrating and evaluating some of these technologies under the SITE program. In one SITE project Retech, Inc. has developed a thermal treatment centrifugal reactor that uses plasma heat to decompose organic compounds and immobilize heavy metals into a glass-type waste. A DOE facility in Butte, Montana, is being considered as a demonstration site for this technology. EPA will evaluate the first month of operation and DOE plans to carry out an additional six months of testing. While radioactive wastes will not be tested, some are similar to the hazardous wastes that will be tested.

In another SITE project EPA hopes to demonstrate a technology developed by the DOE Battelle Pacific Northwest Laboratory and marketed by Geosafe Corporation. The technology is an in-situ vitrification (ISV) process that thermally destroys organic constituents and converts contaminated soil or sludge into a glass and crystalline product. We are currently evaluating several sites for demonstration of this technology.

We have attempted through the SITE program to solicit interest from the private sector to demonstrate technologies specifically for radiation cleanup. In one case, we entered into a joint agreement with the State of New Jersey to demonstrate the cleanup of radioactively contaminated soils. We are currently working with New Jersey to solicit private sector interest in this program.

EPA's Office of Radiation Programs (ORP) has been experimenting in the laboratory with four treatment processes that promise to clean radioactively contaminated soils to acceptable levels. The radioactive materials would be concentrated in a smaller volume for efficient storage, disposal, or further treatment. Initial results with physical separation and soil washing techniques have been very encouraging and we are planning a pilot plant test. Additionally, ORP is experimenting with chemical extraction and magnetic separation techniques that may further reduce the volume of contaminated material.

At a recent meeting with the DOE Office of Defense Waste and Transportation Management we shared information on our mixed waste RD&D efforts and discussed the possibilities for cooperative research and demonstration projects. We believe that there may be opportunities for additional joint demonstrations under the SITE program and for sharing of information and data from our respective RD&D programs. We will be discussing further these opportunities with DOE in the near future. Given DOE's responsibilities for cleanup of radioactively-contaminated sites, it makes sense to pool our expertise and work cooperatively in RD&D of cleanup technologies.

EPA also attacks the hazardous waste problem from the direction of pollution prevention or waste minimization, specifically, from the perspective of either eliminating waste generation or else recycling it. With this approach there are no wastes to be managed--a clearly preferable option. We believe there are many waste minimization opportunities available, as exemplified by the successful waste minimization projects of several large companies. Similar opportunities probably exist in the radioactive waste minimization program area as well. EPA is planning several waste minimization technology research and demonstration projects. Part of this program focuses on cooperative technology demonstration programs with other Federal agencies. We look forward to working with DOE to explore the potential for cooperative projects involving wastes generated from their facilities.

I appreciate the opportunity to discuss our activities with you, and will be glad to answer any questions you may have.

Mr. **Scheuer**. Thank you.

Congressman David Skaggs of Colorado.

Mr. **Skaggs**. Thank you very much, Mr. Chairman.

I apologize for arriving a couple of minutes late.

Mr. Duffy, I'm delighted to have a chance to visit with you this afternoon. Your new position and responsibilities at the Department are, of course, of great interest to those of us that have nuclear refuse facilities in our areas, and I'm wondering if perhaps you could help me understand a little bit better exactly what your jurisdiction within the Department is, what authority you've been given, how you intend to proceed over the next year or two.

Mr. **Duffy**. Well, as special assistant to the Secretary on waste management, I've been given the primary responsibility for coordinating all the defense program waste operations in the five-year plan initially and then to coordinate throughout the rest of the Department the other waste management programs in the same package to ensure that we have a Departmental assessment of the waste management requirements, the environmental restoration requirements, where we stand with respect to compliance situations, where we are out of compliance, what our programs are to get into compliance, and to make sure that we're prioritizing the resources within the Department universally and fairly across the board.

Mr. **Skaggs**. Does that imply that you will have at least some responsibility and authority to deal with the implementation of the five-year plan that you're charged with coming up with?

Mr. **Duffy**. I would think that once we come up with the five-year plan I would be involved in the implementation of it.

Mr. **Skaggs**. And I would then infer from that, to that extent, that would reflect some subtraction of authority and responsibility in that regard that is now pretty much within the province of defense programs.

Mr. **Duffy**. I don't think it's going to subtract, it's going to give them an added resource to work with.

Mr. **Skaggs**. But heretofore they have had the sole responsibility pretty much in that area. Is that correct?

Mr. **Duffy**. Yes.

Mr. **Skaggs**. I'm wondering if, in light of that, you would give me your impressions of the provisions in some legislation I've written, and there may be comparable versions in others, that would really more explicitly take the authority for the clean-up of the weapons plant sites from defense programs and vest it in—in the case of my proposal, ES&H, but there are certainly other alternatives, but isolate that out and give it that kind of attention.

Mr. **Duffy**. I think the Secretary is looking at the restructuring of the Department. I think it would be premature for me to identify what he's going to do. But the under secretary and the deputy secretary are looking at the total organization and will have a recommendation into the Secretary some time in the July time frame.

Mr. **Skaggs**. So the question of who really is going to be in charge of clean-up is an open issue in the Secretary's mind right now. Is that—

Mr. DUFFY. I think it's an open issue, but I can say that all areas of waste management, environmental restoration, and compliance come through me before it goes to the Secretary for final approval.

Mr. SKAGGS. Mr. Brush, would you comment on this issue from your point of view.

Mr. BRUSH. From our point of view, as I said earlier, we're delighted that this issue is being looked at at the Cabinet level at this point. In the past, we've often felt like a voice crying in the wilderness, and we're just very pleased that it's been elevated to one of the Secretary's top priorities.

From the standpoint of the Office of Environment, Safety, and Health, we have always felt and, I think, presented to the Congress our concerns with the concept of our people being put in charge of clean-up when, in fact, we also have an oversight role. We're very comfortable with the oversight role that we have, feel that that independent oversight function is an important one for the Department, and so we're, of course, supporting the Secretary in his effort to look at other organizations, but you will not find us working hard to get the responsibility within our office for that reason.

Mr. SKAGGS. You characterized your oversight role as independent, independent within the Department, an independent voice reporting directly to the Secretary on these issues.

Mr. BRUSH. That's right.

Mr. SKAGGS. Assuming that there were—and I think the hope is that some of the other arrangements that are currently being put together may provide a further independent oversight capability, if that were performed elsewhere, would you feel more comfortable in that circumstance with having more direct responsibility for carrying out the clean-up program?

Mr. BRUSH. We're getting awfully far afield here in terms of options.

Mr. SKAGGS. I don't think so.

Mr. BRUSH. And I'd prefer to defer to what Mr. Duffy said. The Secretary is looking at all these options and will be participating in that, and you'll have a decision shortly.

Mr. SKAGGS. Okay.

If both Mr. Duffy and Mr. Brush, if you would give me your sense of how folks within the Department these days are viewing the Ahearn Committee and the relationship between primary officers of the Department and the Ahearn Committee in getting its mission accomplished.

Mr. DUFFY. I've met with the Ahearn Committee a few times with regard to the waste management issues, and from our standpoint any overview by them is felt to be an area of assistance to us. They were concerned about whether or not they had the right mix of talent within the committee to look at the total waste management operation, because it's a very broad field, and that was one area they felt they needed additional expertise, but from what I've seen in the last month, we've taken their input. I spent an hour with them telling them what we were doing, and we had a very good dialogue, in my opinion.

Mr. SKAGGS. Do you think Departmental people are leveling with the Ahearn Committee in a timely fashion about problems or potential problems within defense programs?

Mr. **Duffy**. I would hope so. You know, I have no reason to believe otherwise. I think the one thing the Secretary indicated is that—and, in fact, it's in his testimony—that you never shoot the messenger. The messenger has reasons for bringing a subject up, and you should reward him for bringing the subject to the attention of anybody—the Congress, the advisory committees—and that's his mode of operation. So I believe from his standpoint he wants everybody to deal directly with the committees that have concerns.

Mr. **Brush**. Let me just comment, if I can, from the standpoint of environment, safety, and health.

Mr. **Skaggs**. Sure.

Mr. **Brush**. We've been using the committee extensively for the purposes that it was originally set up for, and that's to provide advice to the Secretary on key ES&H activities across the board. We've been using them to give their expert guidance on everything from what we're doing in the area of reactor restart all the way to the promulgation of safety standards and orders within the Department. They've been very helpful, and we're using them extensively.

Mr. **Skaggs**. And my question was not, as I hope you heard, directed at ESH but at the DP side. I just had been informed that, for instance, after the Ahearn Committee visited Savannah River and supposedly reached understandings there, that they would receive prompt notification in the event of any problems, that it was a week after the August incident with the P reactor that the Ahearn folks were advised, and that was from a reporter's question, and that didn't seem to be reassuring about the forthcomingness of the people at DP about keeping that channel of communication open.

More recently, at the time that the Ahearn Committee visited the Rocky Flats plant, there had been a subsequent incident involving a spill of chromic acid that was known to people on site at the time but was not disclosed to the Ahearn Committee, and those kinds of things create some questions for me, and I'm just wondering if that's getting worked out.

Mr. **Duffy**. I think from the Secretary's standpoint he feels that there is considerable area for improvement in communication exchange of that nature, and I think the personnel who are involved will get adequate direction in that area.

Mr. **Skaggs**. Mr. Brush.

Mr. **Brush**. May I also comment on that?

Mr. **Skaggs**. Yes.

Mr. **Brush**. I think what Dr. Duffy said is exactly right. We know that there have been communications problems in the past. There's one that we—some of us testified to a couple of months ago involving the water hammer accident—incident at Savannah River. The fact is that we have put in place requirements for immediate notification. The important thing now is to get management out in the field sufficiently alert to this so that when something of this nature happens the first thing they think about is, have we told the people who need to know that, not only in Washington—bureaucrats aren't the only ones that need to know these things—but the people who can do something about it? And, no, that has been a problem, and we're getting there, but it's slow.

Mr. SKAGGS. Yes. I certainly appreciate the change in both internal and external demeanor and policy in this area that has occurred in the last year and a half or two and seems to have a very high priority for the new Secretary.

I hope it's also understandable to those of you in the Department that the continuation of these kinds of things, however minor individually they may seem, makes it more difficult, I think, for us to continue to live with the notion that the Department's internal capabilities at oversight are all that's required and why some of us continue to feel that we need to move to some independent external agency that would have some of these responsibilities.

Mr. DUFFY. I guess I don't know that an oversight committee—as the Ahearn Committee was not on site when the occurrence took place at Savannah River, it's hard to see that an oversight committee would improve that.

I think, as Admiral Watkins indicated, he's got a major challenge in the cultural mentality that existed for a long period of time, and there was and there is in the Department a requirement for control of confidential material, and that was ingrained in the personnel. The decision on what's classified and what's not had been ingrained for a 40-year period, and what he's trying to do now is to make an understanding of who has to be informed on problems, rapidly to inform the States and the local authorities in any cases where there's a spill, and that's going to be a problem for us to get that message out, test it, and make sure that it's out.

Mr. SKAGGS. Mr. Chairman, I have some additional questions, but let me yield back at this point. I know my colleague from Washington State is anxious to engage in the discussion as well, and if I could take some time later on again I'd appreciate it.

Thank you, Mr. Chairman.

Well, I don't want to keep Mr. Morrison at bay.

Mr. SCHEUER. All right. We'll go to Mr. Morrison, and then we'll come back.

Mr. SKAGGS. Thank you.

Mr. SCHEUER. Sid Morrison.

Mr. MORRISON. Thank you, Mr. Chairman.

Mr. Chairman, it's almost, I think, a moment in history worth noting. The offices represented here didn't even exist a few years ago, and to have EPA and DOE at the same table is worthy of note, and working together. I think we shouldn't let that pass.

Mr. SCHEUER. Yes. Not only did the office not exist, but even if it had existed, the likelihood is, without getting into individual personalities and noting that Mrs. Malaprop said that comparisons are odorous, that under almost any Secretary in living memory, if the office had existed, it would have gotten little or no support from the Secretary, and now they have a Secretary of great brilliance, great dedication, who I feel is going to give this office full support and full encouragement and a lot of personal attention. So from that point of view, we're doubly blessed in having the office and having a Secretary who is going to make sure that it works.

Excuse me, Sid.

Mr. MORRISON. No. Thank you. I'm sure everyone appreciates those comments.

Mr. Duffy, perhaps for both you and Mr. Brush, since we're being fairly informal today, I'm very interested in this interface between the five-year plan and this year's budget. Are we—do we need to shift in the direction that you can anticipate, or are you totally supportive of the budget that we have in front of us because of its compatibility with what you think the five-year plan might bring forth?

Mr. DUFFY. Well, I'd like to give you a definitive answer, but as of today the first budget I have the details on is tomorrow with the Hanford site coming in to present the input into the five-year plan.

The admiral's direction was to confirm that the budget that was submitted for 1990 is adequate, and that's what we're trying to do. We may have to look at it in the reprogramming area later on because there are certain agreements that are out there now that we may have to incorporate in a different manner. But we will not be finished with the first cut until June 15.

Mr. MORRISON. There will be a tendency here, as you know, for people to force money at you.

Mr. DUFFY. Right. That's an unusual situation to be in, but we don't want to take the money if we can't use it effectively, and that's what the whole objective was. When the admiral said he needed the confidence to look at the budget and get the input and see that he believed that it was adequate, then he would come back to Congress and identify what needs he had.

Mr. MORRISON. You mentioned it, but I'd like to ask in more detail, how do you see some of the agreements that are being reached now with various DOE sites—how you see those interfacing with the five-year plan, or are you—because of the agreement nature, are you going to have to incorporate them in their entirety in the plan, and do they not then perhaps subvert the direction you might otherwise take?

Mr. DUFFY. I think we've been fairly successful in the month that I've been on board; let's put it that way. I can't speak for the corporate data base, but we have been successful with the States in working within the agreements. The agreement for Washington is still out for public comment and won't be finished until tomorrow. The '90 plan does have the requirements for the Hanford agreement in the '90 budget.

The up-front years are a low-cost year, because there are remedial investigations. As you probably recognize, the Hanford operation has a two- to three-year remedial investigation program going on to get into the out-years. I don't think you'll see the large dollar amounts in the five-year period from an implementation standpoint.

Mr. MORRISON. I think a vital issue and one certainly that comes very close to the charter of this subcommittee is the role of new technology in the total environmental restoration area, but also in your five-year plan, and I guess with any question of that has to go—or has to include the willingness of the agency to seek an increased investment in that new technology.

Mr. DUFFY. I agree, and what we want to make sure is, in looking at R&D, we have that as a high focal point in the next five-year period.

Most of the technology that we see currently is, I'd use the terminology of the industry, it's a hog and haul type of operation where you find a problem, the problem is a contaminated soil, you dig it up, put it in a new container and transport it to another area. We feel that's the most inefficient, ineffective long-term solution. It's the immediate solution that we have, and I think in combination with programs coming out of the SITEs program and what we look forward to in the five-year initiation program to get into in situ types of technologies, such as the in situ vitrification as a stabilization type operation, we'll see a better utilization of the money in the long run, and we feel that the R&D programs in the three- to five-year period may affect our out-year planning on the budgets.

Mr. MORRISON. Is there hope from any of you that, in fact, we may find, with some good, fundamental basic research, that we can restructure some molecules, that we can find an answer and render some of these materials benign or manage them in some way? Mr. Oppelt, that's your program.

Mr. OPPELT. I think that the opportunities for rendering them totally benign are going to be rather limited, but I think there are many opportunities to treat them more efficiently, to treat them more cost-effectively, and to really facilitate their containment, and storage, and mobilization in a long-term fashion that would be more acceptable. There are many technologies, as I mentioned, that offer the prospects, with some field demonstration, to be able to do that.

Mr. DUFFY. I think there's another area that we're looking at also that is programmed into the budget—it's in robotics—in case we do have to remove large concentrations of material to protect an environment or protect an aquifer or water source. The efficiency of the current methodology using level A containment and radiation protection gear limits us to about a 40 to 50 percent productivity.

I think there is technology in the robotics area that can be applied to the larger earth-moving equipment that we can take personnel out from both the exposure standpoint and the productivity standpoint, increase our productivity, and reduce costs when we do use the hog and haul method.

But I think that by remediation we have four or five areas in that area that are presently being tested. PCB's at Oak Ridge is one area, and that has been demonstrated as an in situ capability.

If we can separate the volatile organics from the metals, I think we can cut down on our costs very rapidly, and, I think, that technology is around the corner.

Mr. MORRISON. I'm sure a number of us will want to help with the investment in that area, seeing that perhaps being the best return on investment, as opposed to just pushing money to move products around from one location to another.

Mr. DUFFY. Right.

Mr. MORRISON. Thank you very much.

Mr. Chairman, thank you for the time.

Mr. SCHEUER. Congressman David Skaggs will continue the questioning.

Mr. SKAGGS. Thank you, Mr. Chairman.

Mr. Oppelt, one thing I wanted to check on with you: I assume that your office at EPA is the place which will be reviewing the nonmigration petition in connection with WPP, or is that elsewhere in the organization?

Mr. OPPELT. I'm not familiar with that, sir. It's somewhere else.

Mr. SKAGGS. Gosh, I can't ask you that.

Mr. OPPELT. The Office of Solid Wastes will be doing that.

Mr. SKAGGS. Given that the constituent of primary, or at least substantial, concern in the wastes to be located in WPP are its radionucleides, I'm just curious then why you are not aware of or involved in the evaluation of the nonmigration petition.

Mr. OPPELT. Our principal role in Cincinnati is the evaluation and demonstration of technologies and how well they work principally for Superfund sites, and most of our activities have been in hazardous waste and more nonradioactive type waste situations. We've been participating with DOE, as I mentioned, in a couple of site demonstrations that are applicable to radioactive sites, and we've done these reports, but we don't really have that extensive a program in Cincinnati for radioactive waste in that regard.

Mr. SKAGGS. Mr. Brush, it's my understanding that job, within the DOE structure, exists currently through administrative action; that is, it does not have statutory authority. Is that correct?

Mr. BRUSH. Under the DOE Organization Act, the Secretary is required to designate one assistant secretary responsible for the area of environment, safety, and health. So although there's no requirement that a particular assistant secretary be designated for that single particular function or group of functions, the fact is that there is within the DOE Organization Act a requirement that one of the assistant secretaries be given those functions, and those, of course, are presidential appointments, Senate confirmation.

Mr. SKAGGS. Yes, I understand that, but under the act it could be given to the assistant secretary—

Mr. BRUSH. There's no requirement such as the one in your bill, if that answers your question.

Mr. SKAGGS. I'm just advised that the act covers environment and health and not safety specifically. Is that right?

Mr. BRUSH. I think that's right.

Mr. SKAGGS. Would you think it well advised for us, whether it is in my bill or any other, that we recognize explicitly in statute as a separate responsibility within the Department the functions that are now administratively under your jurisdiction?

Mr. BRUSH. Let me try to answer your question this way. The Department has not officially taken a position on your bill at this point, so I can't speak definitively for the Department. We have, however, in the past expressed concern that the Secretary be given the flexibility to assign responsibilities to the assistant secretaries that are named under the DOE Act in the way that he best feels meets the needs of the Department, and I think moving down the road, starting to require that certain assistant secretaries do certain things is going to take away from that flexibility, and I suspect that that may be one of the issues that has to be looked at before we take a position your bill. That has been the position in the past. I think it's a valid concern, one that will have to be looked at.

Mr. SKAGGS. I think we are all well aware that, in addition to management flexibility on the part of the Secretary, which I recognize as a very valid concern, that we're in an environment outside of the Department now that is particularly sensitive to assurances and the maximum kinds of guarantee that we can have that particular concerns are going to be given particular priority within the Department and at least—again, I'm not trying to push my bill, but the idea that it would perform, I think, a very useful public—send a very useful message to the public that the Department is sufficiently committed to a concentrated and focused effort in this area that it feels comfortable with the idea of giving it statutory life.

Mr. BRUSH. We continue to feel comfortable within the office the way it is now, and I would note that the Secretary—the President, excuse me—has sent forward to the Senate a nominee for the position of assistant secretary, environment, safety, and health, recognizing that it would cover those functions.

So I think my reaction would be as a professional within the Department that we're doing the job, we're getting the support we need to do it, and whether it's enacted in statutory form isn't going to affect that at this point.

Mr. SKAGGS. I hope that's correct, and under this regime I'm reassured, but we've been through a lot of roller coaster rides in this area, and we're looking for, I hope, some long-term assurances.

I hope it would be possible for us to get the Department's position on my bill for the record, if you could submit that later on.

Mr. BRUSH. It is being developed.

Mr. SKAGGS. Back a few months ago, the General Accounting Office at least was reported to have made statements along the lines that some of these areas around the country are sort of beyond repair and will need to be looked at as, I think the term was used "national sacrifice zones" of some sort, fenced off, cemented over—whatever—and protected from incursion for hundreds or thousands of years. I'm wondering if you all would express your understanding of what the Secretary's view is of that kind of assessment as opposed to what I believe has been his commitment that we're not going to fall into that kind of characterization but will be committed to getting these places cleaned up.

Mr. DUFFY. I think the aspect that he looked at was, the technology to take all the zones or all the contaminated areas at this time doesn't exist, and what his objective is, is to assess whether or not that technology was in the finite time period of what's considered as institutional control, 100 years.

It may develop over the time period that these areas can be restored. I think there are certain areas that may not, and we have not come up with a final Department opinion on that, but I think in the majority of cases we are going towards what we can do to develop how clean is clean. That's a monumental step in determining whether or not there is such a thing as a sacrificial zone. That has not been developed yet, and it will be developed over the next decade, I would assume, and when that comes out we will determine whether or not we can clean up the site to those specifications with existing technology.

Mr. Skaggs. So it is an open question anyway in the Department's mind right now whether or not technologies can be developed that will be able to address the range of problems that we are facing.

Mr. Duffy. Right, especially with the time frame that we are talking about. We're talking about a minimum of 50 years for looking at certain elements of clean-up and 100 years in certain elements of institutional control.

Mr. Skaggs. You said a few minutes ago, Mr. Duffy, that we shouldn't expect a great deal of ramping up for the clean-up budget for fiscal '90, particularly because a lot of these sites are still being assessed. The one that I am parochially most concerned about, the Hillside 881 site at Rocky Flats, are you familiar with that one?

Mr. Duffy. Yes.

Mr. Skaggs. That made at least the top of your preliminary priority list.

Mr. Duffy. Yes, sir.

Mr. Skaggs. I've been told, by the people at the Rocky Flats plant anyway, that they are perfectly capable of moving ahead right away on clean-up there; the technologies that will be applied to that site are in hand. Is that your understanding?

Mr. Duffy. Yes. From what I saw of the plant when I was out there, the first step, as I remember it, was an interruption zone using a French drain to collect the leachate coming off the hillside and stop it from any potential going off any further or contaminating other areas and then treating the water from that standpoint. But, again, it's a case of containment, not final solution, as indicated. It still will be radioactive, but it will be contained in the design.

We would like to see future remediation projects that we have the capability of making better residual capabilities for holding them on site. That's a very difficult problem with the present technology.

Mr. Skaggs. But is there going to be any delay in at least proceeding with that stage of clean-up on 881?

Mr. Duffy. No. As far as I can tell, that was in the budget when I looked at it last.

Mr. Skaggs. Okay. I was misunderstanding. I had heard that that was going to be put off a couple or three years to fiscal '93.

Mr. Duffy. I haven't seen that, but they'll come in next—a week from Friday to discuss that. But the French drain I knew was in the present plans. I'll get that corrected for the record.

Mr. Skaggs. I'd appreciate it.

[The material referred to follows:]

COMMITTEE: HOUSE SCIENCE/SPACE/TECHNOLOGY
SUBCOMMITTEE: NATURAL RESOURCES, AGRICULTURE RESEARCH & ENVIRONMENT
WITNESS: LEO P. DUFFY
DATE: APRIL 27, 1989
PAGE 41, AFTER LINE 970

INSERT FOR THE RECORD

DOE is proposing to begin construction of a French drain on the 881 Hillside at the Rocky Flats Plant as an interim measure to contain leachate coming off the site and prevent contamination of other areas.

Construction of a French drain would begin after DOE completes its NEPA review of the proposed action. An Environmental Assessment was submitted by the DOE Albuquerque Operations Office (AL) to the DOE Office of Environment, Safety, and Health for review on June 19, 1989. At least 2 to 4 weeks will be needed for Headquarters review of the documentation submitted by AL officials.

A Finding of No Significant Impact, or FONSI, would be published in the Federal Register if the Environmental Assessment supports such a conclusion. Should this occur, the Environmental Protection Agency (EPA) must approve an Interim Remedial Action Plan before actual construction can begin. DOE has no estimate of the time this final step will take before it can commence work on this interim measure. Funding for this project is included in the FY 1990 budget request.

Mr. **Skaggs**. As I understand it—well, let me ask you, what are the plans for State and public review of your five-year plan, and what's the timetable for that expected to be?

Mr. **Duffy**. We don't have the final approval from the Secretary on it. We have a conceptual approval from the standpoint, we have discussed it with the Virginia Tech to be a facilitator to bring in the sociological. Our original intent was to ask the National Academy of Sciences to expand their capability to handle sociological and legislative and ecological groups. They said they were committed to only the technical assessments. So we looked for a university that we could bring on board quickly. We had an active agreement with Virginia Tech.

We have contacted the National Association of Attorneys General, the National Association of Governors, and we have some names; we don't have agreement on a name from Colorado at the present time, but in talking to the people and last month out at Idaho in our monthly meeting we thought we had agreement that we could get a nomination from Colorado.

Mr. **Skaggs**. And that, by implication anyway, suggests that you're looking for only a single individual from each of the States affected?

Mr. **Duffy**. No. What we did is, we asked the associations for representative people, recognizing that in order to get through the four-month period if we got a representative from every area and tried to accommodate their schedules it would be almost a physical impossibility to get through both the review and their schedules.

In the case—as an example, we talked to Washington and Oregon, and they agreed that one person would come in to represent both of those States. We're looking for regional areas from the National Association of Attorneys General, one from the west and one from the east, to get a cross section to go back to the organizations. We haven't got the final group together, but it looks like it's going to be somewhere between 15 and 20 people in the sociological, legislative, and ecological area. There's about 13 to 14 in the technical area. The time frame for the meetings are the second week in June for a week, the two days in the first two weeks in July, and one day in the final week of July before we put the draft to the Secretary.

Now there are some administrative areas. We can't put out budget information formally until it comes through the Secretary, through OMB, but we will try to put it into the category of what we see as the areas of priority.

Mr. **Skaggs**. I can't comment on other States. I would certainly expect that officials concerned with this area in Colorado would accommodate their schedules to yours and that we would probably welcome the opportunity for more than one individual to participate so that we can cover some of the technical stuff that isn't in one individual's competence. Is that a problem from the Department's point of view?

Mr. **Duffy**. No, I don't see it as a problem.

Mr. **Skaggs**. Great.

Mr. Chairman, again, I don't want to abuse the privilege the chair's given me in this, and if Mr. Morrison or yourself wants to take over for a while, I will yield.

Mr. Scheuer. Do you have any other questions?

Mr. Morrison. No additional questions, Mr. Chairman.

Mr. Scheuer. Well, I'll come in with a couple of questions, and if you have a few remaining we'll recognize you later.

Mr. Skaggs. Thank you.

Mr. Scheuer. Mr. Brush, the General Accounting Office has reported and, frankly, DOE has admitted, that it's unable to give a full cost accounting of the funds expended for environmental cleanup and remediation. Has this situation been improved?

Mr. Brush. *Since our last time that a witness from this office* had the opportunity to discuss this with you, Mr. Chairman, we have looked at that very hard, and there has been over the past year an attempt to remedy that. There is now in place inside the Department a program called the Environmental Activities Reporting System, EARS, or "ears" to those of us who work it, which is located within the Office of Management and Administration and the Budget Office and is a cross-cutting exercise which is intended to record all of the expenditures in the Department in these areas.

In addition, that is a base activity that is being looked at in the context of the work that Mr. Duffy is doing in order that we have a Department-wide agreement on how we are going to characterize and monitor these activities.

Mr. Scheuer. How much money is being spent in this area during the current fiscal year and also in 1990? What do you estimate will be spent in this area in 1990?

Mr. Brush. Would it be possible for me to provide that for the record?

Mr. Scheuer. Sure. By all means.

Mr. Brush. I hesitate to give a number and then give a wrong number.

Mr. Scheuer. No problem.

[The material referred to follows:]

Insert for the Record
Statement of Peter N. Brush
Scheuer Subcommittee Hearing; Page 45

Planned Obligations: Total DOE[1]
(Dollars in Millions)

	FY 1989	FY 1990
Environmental Restoration (Clean-up)	445.8	645.5
Environmental Compliance	227.1	437.1
Radioactive Waste Management	602.6	584.7
Sub-Total	$1275.5	$1667.3
Base Program - Environment	327.7	348.2
	$1603.2	$2015.5

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[1] Data taken from EARS Report; March 8, 1989. Figures do not include Naval Reactors environmental program and the West Valley Demonstration project.

Mr. SCHEUER. Mr. Oppelt, proponents of biotechnology often express the hope that biotechnology will have some applications in the area of hazardous waste treatment, and we've all heard the dreams and hopes of microbes that eat their way through solid waste and leave a bed of Chanel No. 5, and, really, the potential, as has been expressed, of biotechnology creating organisms of some kind that will eat their way through this fog of waste is very exciting. Are there any encouraging developments that you can cite for us? Are you funding research in this area? Do you expect to have some results in the not too distant future?

Mr. OPPELT. Yes, we are funding research in that area. There is an inter-laboratory work group and steering group that combines the talents of many of our research labs in EPA into a work group for biosystems engineering, and we—like you, we agree that there are many opportunities for using biotechnology, particularly, in our case, the enhancement of naturally occurring organisms, to facilitate the disposal of hazardous waste. Not only in situ is a possibility but also in terms of treating wastes once they have been removed from a site.

Some of the attractive areas that we are exploring right now are the use of a naturally occurring organism called the white rot fungus which has a capability of metabolizing lignin-type materials, which can be things like dioxins, for instance, 245-T, and pentachlorophenol as a way of bioremediation of sites that contain those types of materials. There are also naturally occurring organisms which we're trying to adapt to the disposal and in situ treatment of PCB's for instance.

Mr. SCHEUER. Do you have anything on board that you're looking at that would have a potential application for something like the Exxon oil spill in Alaska?

Mr. OPPELT. We are working on that this very—as we speak, looking at some possibilities for accelerating what would normally be a natural bioremediation of those types of materials in the manner that we think has some possibilities.

A couple of the things we're looking at are enhancing the nutrient balance in that particular area because it's been shown that by enhancing the amount of nitrogen and phosphorus available to the existing organisms they can accelerate their rate of growth, and that's been done in other situations although not in the particular situation we're talking about up there in Prince William Sound.

Another option would, of course, be to try to enhance other naturally occurring organisms that perhaps are not there and to see if you can inoculate the beaches and materials to accelerate the degradation of the oil.

Mr. SCHEUER. Not only the beaches but conceivably some microorganisms that could be applied to animals—the wildlife, the birds, the animals. It's just heart-breaking to see the pictures of those animals dying in this glutinous mass—mess. It's awful.

Are there any legal or social impediments that you know of that might mitigate against or deter the use of organisms, either plants or microbes, for this purpose?

Mr. OPPELT. I think in the case of naturally occurring organisms what you're really doing is just enhancing the ability of organisms that are already there, and my personal opinion is, that's one of the most fruitful areas for us to pursue.

In the case of taking organisms that are not indigenous to a particular area, there are social concerns that come up. I understood that there probably is some resistance even in Alaska to bringing organisms in, if you had to do that, that weren't indigenous to that particular area.

Mr. SCHEUER. They would have to make some real tough value judgments as to the risk and the benefits, and that would be an excellent laboratory. They have horrendous damage being done, horrendous damage facing them, if the current mess isn't cleaned up.

For example, I understand from reading the Wall Street Journal a week ago that a lot of the oil that is seeping up on the—out of the water on to the sand is seeping through the sand and then going into underground reservoirs there and are likely, through the action of tides, and waves, and currents, and what-not, to be drawn back to the surface in the future. So they're not really in a holding subterranean cavern where they're sort of out of the way and forgotten, and the article mentioned that they were likely to be seeping back and then seeping down again and seeping back, and that this could continue over many, many, many decades.

That means that the cost of not catching that oil spill before it hits the beach, or at least immediately after it hits the beach, and letting that oil go down where it's sort of in a—takes on a life of its own, seeping up and back and up and back over the generations, it is an awful cost, and if I were the governor of Alaska I would have some agonizing choices to make between taking some risks of cleaning the stuff up fast or facing the known cost of having that stuff around polluting the environment for generations to come.

Mr. OPPELT. I agree. It's a tough decision.

We're hopeful that some of the testing and evaluation that we would do for use of naturally occurring organisms would bear some fruit here this summer through some testing.

Mr. SCHEUER. One would certainly hope so.

Once Federal funds have been used to develop a particular environment remediation technique, what happens? Is there ready transferability to—from applied research, from first the basic research, then applied research, and then out there in the field? Does the private sector grab it? Do State agencies grab it? How is the technology transfer process taking place? And is there anything you can think of that we could do at almost any level of government to encourage the rapid application of new technologies, biotechnology or any other technology, that we develop in the labs?

Mr. OPPELT. I think there are two ways this can happen. One way, which the Congress has given us, is the SITE program, and that enables us to assist the private sector in demonstrating the technologies that they see as being needed for remedial action by virtue of our assisting them and doing the evaluation, and hopefully an objective evaluation, of their technology and where it can be applied, because we've seen that inability in many cases to find sites and find opportunities to demonstrate the technology in the field on actual hazardous waste sites as being a limitation to the acceptance of those technologies by the States and by our regional offices in terms of folding these into actual remedial clean-ups.

In the case of our own technologies that we have tried to enhance and speed up the development of technologies that the private industry isn't doing, I think the real vehicle that we see in that case is the Federal Technology Transfer Act, which we have been working with the private sector to enhance the transferal of some of the technologies we've developed to get them into the private sector.

In January, we had a trade fair in Edison, New Jersey, where we invited industry in, and these were vendors and developers of technology. Some 150 companies showed up at this particular meeting, were given presentations on three technologies that we are anxious to try to commercialize and get industry to commercialize: a mobile soils washer, a mobile carbon regeneration facility, and a mobile soot facility for injection grouting or extraction of materials from Superfund sites.

Almost 300 people came to this representing these companies, it was very successful, and we've asked them to submit proposals to participate with us in terms of Federal Technology Transfer Act agreements, and we have three companies we are actively pursuing these agreements with in terms of the soil washer and one company we're pursuing it with for the mobile carbon system as well.

The same thing has happened with our mobile incinerator that's been out in Missouri. A similar meeting was held for that, and we're expecting proposals in on that in the end of May.

Mr. SCHEUER. Well, I think—

Mr. OPPELT. There's a lot of interest in it.

Mr. SCHEUER. Pardon?

Mr. OPPELT. There's a lot of interest on the part of the private sector.

Mr. SCHEUER. In the private sector. They're moving in.

Mr. OPPELT. They're moving in. They're very anxious to work with us. As a matter of fact, they are very surprised that the Government is coming to them with an offer to work cooperatively on developing technology, but I think it's taking hold; it's going to be very successful.

Mr. SCHEUER. That's encouraging.

There's been some talk that the environment for Superfund is one in which hazardous waste disposal technology seems biased in favor of existing technologies. Does that reflect your view? Is that accurate? Are there any special efforts under way to facilitate the introduction of innovative technologies for these problems?

Mr. OPPELT. Again, I think the SITE program is the prime example there in terms of demonstrating innovative technologies that we review, proposals for—from industry to facilitate the demonstration in real hazardous waste site situations of those technologies to collect credible data on their performance, on their limitations as well, and on their costs, so that these kinds of unbiased information can be factored into their adoption and actual remedial action.

Mr. SCHEUER. One hears that we're still using waste technology—waste disposal and treatment technologies that are considered passe in Europe—outdated, antiquated. To what degree is this true, in your view, and, if it is true, why is there a technology lag in this area?

Mr. OPPELT. It may be true to some extent. There are some different technologies that have been applied in Europe, particularly in the area of soils cleaning, that we have been following and collaborating with, at least in terms of exchanging information, with the Europeans.

Our hope is that we can begin getting people in this country more familiar with those technologies. In fact, this June in Atlanta we're sponsoring an international conference where we're bringing approximately 15 technology developers from Europe into this meeting to make presentations with our own site developers at the same time, and all indications are, this is going to be a very well attended meeting that would enable people in the United States to get more familiar with the European technologies.

Mr. SCHEUER. So you feel that they are ahead of us?

Mr. OPPELT. In certain respects, and in other technologies they haven't really applied them. It's not a completely one-way street on that. I think in many respects in the monitoring, in the emissions measurements, and performance measurements, we are farther ahead of the Europeans. They're very good at equipment in many cases, but they don't pay quite as much attention to the emissions performance as we have in this country.

Mr. SCHEUER. Is there a two-way technology transfer process that's there?

Mr. OPPELT. Yes.

Mr. SCHEUER. Where we're ahead of them, them to us? Where they're ahead of us?

Mr. OPPELT. It's a two-way street.

Mr. SCHEUER. It's happening.

Mr. OPPELT. It is happening. We're working with the NATO organizations in terms of transferring information from our technology developments to the NATO countries, and they have been meeting with us, really, over the last 10 years but more in vigor in the last few years in these remedial technologies, which I think is a very good communication; it's working very well.

Mr. SCHEUER. Sure it is.

Is DOE using these new technologies?

Mr. OPPELT. I think that in the case of the in situ vitrification, which is one of the site technologies, my understanding is that DOE is interested in that, that it is one of the technologies that they're proposing for demonstration out at Hanford.

Mr. DUFFY. They have two areas that are using in situ vitrification. One is Idaho, because of the heterogeneous mix above the Snake River aquifer, to stabilize that with a glass form. The second area we're using it is in the single-wall tanks to stabilize the sludge in the single-wall tanks in a glass form which would then pass any leachate characteristic test.

I think one of the reasons the Europeans are using equipment is, they don't have the benefit of the large land mass that we have, and, as a result, our cost, when it was disposed in land, was a lot cheaper than the costs associated with incineration or high-energy technologies, and we're now suffering the long-term effects of using an inexpensive technology up front when a more expensive technology might have been a satisfactory solution.

Mr. OPPELT. A good observation.

Mr. SCHEUER. Congressman David Skaggs.

Mr. SKAGGS. Just a couple of other questions, Mr. Chairman, and then, if I may, I'd like to ask consent to submit some additional questions for the record.

Mr. SCHEUER. Very good.

Mr. SKAGGS. Mr. Brush, you've described your position as the independent oversight mission within the Department. What authority, either by Secretarial direction or tradition or any other source, do you have to really effect compliance with appropriate health safety standards on the part of defense programs?

Mr. BRUSH. Well, the first authority we have, if you will, is, of course, by having a direct reporting line to the Secretary, a jawboning authority, and we have not only the authority but the responsibility to, as it were, bring bad news to the Secretary when he needs to hear that. That has been a function that has been carried forth in the past couple of years, as you know, and it's one that has been used, I would use the term "aggressively," and has been effective.

With respect to legal enforcement within the Department, there was a—the DOE order system was revamped back in 1986 after the formation of this offer—this office, to give to the assistant secretary for environment, safety, and health the ability to require shutdown of facilities where there's an imminent threat to health and safety of the public. That authority still exists. It's one that's very important, of course, since it's one that underpins the advice-giving role of the assistant secretary.

We have also been working on other amendments to these orders, which we hope will be approved in the coming months, which will give us authority beyond just the—if you will, the sledge hammer approach of shutdown and give us other abilities to require taking of certain actions by field offices and by contractors where we perceive that need to exist either for health reasons of the workers on the site or more general public health and safety. We're not ready to go with that yet. We do perceive a need to do that, and we hope that will be coming forth in the coming months.

Mr. SKAGGS. Has the authority that you referred to on shutdown been exercised by you or your predecessors?

Mr. BRUSH. Thus far, that particular authority has not had to be exercised. Where there have been decisions to shut down, they've been made as a Departmental decision, not by the assistant secretary directly.

Mr. SKAGGS. And, actually, the assistant secretary's authority exists only in the absence of the Secretary or the under secretary's. Is that correct?

Mr. BRUSH. That, of course, is right. If it's impossible to get a decision from the Secretary, for whatever reason, the assistant secretary's authority then becomes absolute.

Mr. SKAGGS. But it exists only conditional on the failure of the Secretary or the under secretary to be available.

Mr. BRUSH. The assistant secretary cannot shut down a facility if the Secretary doesn't agree to do that; that's correct.

Mr. SKAGGS. Which basically makes your role in that one of staff recommendation to the Secretary.

Mr. BRUSH. We are an independent advisor to the Secretary; that's clear.

Mr. SKAGGS. And I realize you also have the option of turning Mr. Starostecki loose, which always puts fear in the hearts of people in the field.

Mr. BRUSH. I'll let that one go by.

Mr. SKAGGS. I'm wondering if you can, particularly referencing your resident inspector activities in the field—can you give us just some anecdotal evidence of how that potential authority that you have with the Secretary has been able to empower your on-site people to make a difference?

Mr. BRUSH. I'd really rather not use anecdotes. I think that's a pretty—not a really good way to proceed. But I can tell you this, that the on-site representatives make daily reports, they participate actively in the work that's going on in the field, and their very presence in the field is making a difference.

I'm thinking back to the fact that, in a number of cases, our on-site inspectors, resident engineers, have actually been the individuals who've identified problems in the field, and when that happens, it energizes the field people, the contractors, to work even harder because they don't want to be told these things by the oversight body, they want to find them themselves, and that's exactly the process that we're hoping to create with this system.

Mr. SKAGGS. I understand. With respect to that, it would help us to appreciate more richly the effectiveness of that approach, notwithstanding your reluctance to have some examples, other than that generic description that you just gave me, of when your people, conferring and giving advice to someone in DP, effected a change in procedures or effected compliance, or whatever, that wouldn't have happened a couple of years ago.

Mr. BRUSH. One example that springs to mind: You are all familiar with the water hammer incident that occurred earlier this year in Savannah River. One of the reasons that that was notified—that the notification was given—this ties into your question earlier—was late, and, really, we were the first, just about the first, to learn of it due to the fact that our on-site rep stumbled across the fact that this had happened, and he was making his report, and the fact that he was reporting energized the field people to do their reporting.

So I'll give that to you as one simple anecdote of the kind of effect that having an independent field person can have. I wouldn't want that to be the headline from this hearing, but I would—I offer it as an example of how an on-site representative can, in fact, energize—to use your word—the contractor and the local—and the site people to be more observant and more energetic in performing.

Mr. SKAGGS. How widely, or how completely, are the weapons plants covered with your on-site people?

Mr. BRUSH. We're only getting geared up at this point, Congressman. It's the first year we've had the program. We have six on-site reps at this point. We have another, I believe, 16 in the works, and we're hoping to continue to ramp up very quickly.

Mr. SKAGGS. We could expect full coverage then in the next fiscal year?

Mr. BRUSH. I would hope so.

Mr. SKAGGS. Is that in your budget?

Mr. BRUSH. Yes.

Mr. SKAGGS. And let me please invite you to continue to share success stories with us on this. I think it is of very direct relevance to our making of the appropriate policy decisions about whether we can leave these responsibilities in the ES&H or not, and it's not just a matter of idle interest, I think, on the part of a single Member of Congress.

One final question. If you're going to get the kind of job done that you want to get done, I realize you're going to need to be able to attract the best possible people both from within the Department and without to join the ES&H effort within the Department of Energy, and yet certainly over the post-war years the sexy place to work at DOE has really been in defense programs. Are you going to be able to get and keep the kind of people on a career path in ES&H that we will have to have to have institutional memory and ongoing competence to really join you and others who have chosen that path in making that an effective operation?

Mr. BRUSH. I've been working at the Department for 20 years in very sexy jobs, and I've never worked for defense programs.

But in answer to your question, it is a real problem that you have put your finger on. We agree that ramping up and getting these positions staffed is a difficult one. There's enormous competition right now within both the Federal Government, across the board. We see the demand for nuclear engineers, for the kind of chemical engineers, mechanical engineers, health physicists, and the like that we are looking for. It makes it a very difficult time to hire the numbers and kinds of people that we need. We've got over 60 recruit actions out right now, and they're just not being filled as fast as I would like.

We're not only in competition with the Federal Government, NRC, we're in competition within the Department. We're, as you know, trying to get the—our definition of success will be to get the line organizations in a position where they can do the kind of ES&H work in the first instance that should be done. So we're not only in competition with them but we're in competition with other oversight organizations around the Federal Government in this area. We're also in competition with private industry working in these areas. We simply don't have enough people.

There are a number of initiatives under way. We are looking at a number of programs both in the nature of intern programs and the like that we can use to get these positions staffed and get up to speed, but it is a difficult problem.

Mr. SKAGGS. You mentioned 60 positions out of how many?

Mr. BRUSH. Well, I think—I believe at the end of fiscal '90 we are hoping to be up in the 250 position range for the Office of Environment, Safety and Health and that we'll need all 60 of those to get there.

Mr. SKAGGS. But your current staffing within your shop is how many?

Mr. BRUSH. It's just under 200.

Mr. SKAGGS. So you've—

Mr. BRUSH. We have all those—we're hiring against all of those positions, even some that we don't have.

Mr. SKAGGS. Mr. Chairman, thank you very much for the time.

Mr. SCHEUER. Thank you, Congressman.

Well, I want to thank this panel for their very interesting testimony, but we've got to ramp up and get on with the next panel. Thank you very, very much.

Mr. OPPELT. Thank you, Mr. Chairman.

Mr. SCHEUER. I would ask unanimous consent that an opening statement by the ranking minority member of this committee, Congressman Claudine Schneider, be placed in the record at the beginning of this hearing immediately after my opening remarks.

There being no objection, so ordered. Thank you very much all of you.

We will now hear from the second panel: Dr. William Wiley, Dr. John Whetten, Dr. Robert Schock, and Dr. Tim Myrick.

All right. Thank you, gentlemen. We're happy you're here and we appreciate your coming and we appreciate your patience because it's late on Thursday afternoon.

Why don't we take you gentlemen in the order in which I mentioned your names? Dr. William Wiley, Director of the Battelle Pacific Northwest Laboratory.

Your prepared testimony, all of you, will be printed in the record at the point at which you speak, so I invite you to forsake the printed page and chat with us informally for 5, 6 or 7 minutes. Then when we get through the panel I'm sure we'll have some questions for you.

STATEMENTS OF WILLIAM WILEY, PH.D., DIRECTOR, BATTELLE PACIFIC NORTHWEST LABORATORY; JOHN T. WHETTEN, PH.D., ASSOCIATE DIRECTOR, LOS ALAMOS NATIONAL LABORATORY; ROBERT SCHOCK, PH.D., PROGRAM LEADER FOR ENERGY, LAWRENCE LIVERMORE NATIONAL LABORATORY; TIM E. MYRICK, PH.D., MANAGER, OFFICE OF WASTE MANAGEMENT OPERATIONS, OAK RIDGE NATIONAL LABORATORY

Dr. WILEY. Thank you very much, Mr. Chairman, and members of the subcommittee. It is a pleasure on behalf of the Northwest Laboratory to be here. I think your subject is one of deep concern, and I think this next 10 years will be a period of the environment. I think it is time we get on with these issues. However, every aspect of this whole problem, including the problem with DOE, is one of requiring technological innovation.

Before I discuss some of the technological innovations that we're involved in at Pacific Northwest Laboratory, I would like to give you a little background so that you can see how we got to the position of recognizing the Pacific Northwest Laboratory as the laboratory. Our mission is the environment.

In 1964, the Department of Energy or the predecessor of the Department of Energy, the Atomic Energy Commission, fractionated or segmented the Hanford site into research and development and defense program operations. Battelle Memorial Institute was given the contract for the operation of the Pacific Northwest Laboratory.

At this time the laboratory began a 25-year-long transition from a laboratory devoted to materials, defense program materials development to what is now one of the five multi-program national laboratories.

Over the course of these 25 years we have worked for every agency involved in the environment: NOAA, EPA, the Department of Energy, others including industry, for that matter. Interior and others, for that matter.

Over these 25 years we have recognized the problems as they have come along such that now about 40 percent of our present $250 million budget is directly associated with environmental research and development. These include such areas as radioactive and hazardous waste cleanup, acid rain, global environmental change, and, of course, the major problems that we're having with indoor air quality, the radon problem.

In addition, we are the independent environmental monitoring, research and development arm for the Hanford site. Since we're not involved in operations and are required to publish everything that we do in the regard to research and in regards to monitoring of the Hanford site, we are the independent oversight. And, as you recognize from our published information, the Hanford site is reported to have many of the major problems that exist throughout the, throughout the DOE complex. So we've had an opportunity to investigate in a real sense some of the major problems associated with waste cleanup.

Now I will turn to a discussion of some of the activities that we're involved in at the present time, and I'll start by discussing the Office of Environmental—Health and Environmental Research, which is a component of DOE that we got involved with approximately two years ago, associated with a subsurface behavior of contaminants program.

What we're talking about here, Mr. Chairman, is the fact that when you get materials into deep aquifers, pump and scrub does not work. You must take advantage of the microorganisms which we have discovered are in these very deep aquifers, and we are looking at the process of using that through, through the evaluation of modern chemical and microbiological techniques to surface methodologies that will permit us to in situ treat these deep aquifers.

The objectives of this research was to develop the scientific and technological foundation to enable DOE to assess its underground contamination problems and to conceptualize and develop innovative technologies to isolate, immobilize and destroy wastes that are already underground, and funding for this program has been provided by the DOE in FY '89.

When the Department of Energy recently conducted a comprehensive review of the hazardous waste sites of DOE, the magnitude and complexity of its remediation problems became evident. The cost of remediation, GAO's estimate being in the hundred billion dollars or more, is just an unrealistic thing to think about in terms of today's budget. It also is impractical to believe that the sheer volume of contaminated soil that we have in many of these sites can be moved to—from a site of high risk to a site of low risk. Just does not match.

In the case of groundwater, it cannot be easily pumped and treated, as I described, in the deep aquifers. Furthermore, DOE wastes are far different and more complex than the wastes generated by other operations such as chemical manufacturing companies. DOE's unique wastes include various combinations of radioactive materials, heavy metals and organic chemicals. In some cases even biological contaminants are included. Therefore, it is clear that new and innovative concepts and technologies are needed to evaluate and to remediate these situations in situ—on the site—to reduce the overall costs and health risks of remediation, of the remediation process itself. Pumping and scrubbing is not the way.

You have heard the description of the in situ vitrification process which developed out of very fundamental basic research and has evolved into a process, and I have an example here, Mr. Chairman, of in situ vitrified soil from the Hanford site which, which does not contain any contaminants because we wouldn't—we would have had to get that release from DOE. But it is—it gives you an idea of how you can take these wastes and immobilize them such that they are no longer soluble and cannot be moved throughout the environment.

Taking into account all of these factors and the Department—the Department then has created the concept of the Environmental Research Center of Excellence. The Department of Energy just announced the creation of this research center and we anticipate its funding in FY '90. The center would be the Department's center for environmental research and development for new and innovative environmental restoration technologies that have the following objectives: reduce the time and costs required to characterize DOE waste management sites; to reduce time and costs to remediate the waste sites and inactive facilities that exist at these sites; third, to increase the legal and regulatory defensibility of the remediation process.

I might add, Mr. Chairman, that we all recognize that one of the big problems we are going to have is the process of permitting these sites. Once you have cleaned them up you must permit these sites.

Within the FY '90 budget, this Environmental Research Center of Excellence will receive $6 million; $4.2 million of these dollars will be operating and $1.8 million for capital equipment for this program. The FY '90 budget request, if approved, would be allocated to research on understanding fundamental physical, chemical and biological processes in the underground water environment; developing new and sophisticated sampling and measurement techniques; and exploring the use of native underground microorganisms, as I described previously, to detoxify and destroy these wastes.

Planning for the Environmental Center—Research Center of Excellence also assumes the development of a scientific user facility. This is the way we hope to get around to the technology transfer that you were discussing earlier. If you have industry coming in to utilize these user facilities, you have the opportunity to get them trained, to get the workforce trained, and to get them utilizing the technologies that come out of the laboratory.

These technologies would be documented or field tested in the nearby Hanford site, which we have access to, and, as you know, Hanford is believed to be one of the most contaminated of the sites.

In summary, the environmental problems facing us as a nation are staggering, we believe. The Superfund program is an example. The Federal Government's environmental remediation program for Federal lands is another. Nevertheless, the challenge for all of us is to proceed in an expeditious, cost-effective manner with the task of remediation. Get on with the task.

The Pacific Northwest Laboratory has a long history of conducting research and development programs that are directed toward solving national problems in the environment. The Environmental Research Center, which I just described to you, we hope will become the prototype for such research centers throughout the country, throughout the national laboratories.

[The prepared statement of Dr. Wiley follows:]

Statement of

DR. WILLIAM R. WILEY

Director

Pacific Northwest Laboratory

Before the

Committee on Science, Space, and Technology

Natural Resources, Agriculture

Research and Environment Subcommittee

United States House of Representatives

Washington, D.C.

April 27, 1989

Mr. Chairman and Members of the Subcommittee, on behalf of the Pacific Northwest Laboratory, I am pleased to be here today to discuss our research and development efforts aimed at developing innovative approaches for the management of hazardous wastes. I am Dr. William Wiley, Director of The Pacific Northwest Laboratory (PNL) and Executive Vice President of Battelle Memorial Institute.

Before I describe the significant role that PNL has had for many years on all aspects of environmental research and waste management, I believe it would be useful to the Subcommittee for me to briefly discuss the evolution and overall mission of PNL, which is operated for the Department of Energy by Battelle Memorial Institute.

When the federal government segmented the contract for management of Hanford operations into several distinct scopes in 1964, Battelle's proposal was selected to manage the research and development portion of the operation. With those decisions, the Pacific Northwest Laboratory (PNL) came into being. In the intervening 25 years, the Laboratory's programmatic mix has evolved from one whose principal function was to support the nuclear materials production mission at the Hanford site to being one of DOE's multiprogram national laboratories supporting a whole array of research and development programs for DOE, as well as EPA, NRC, DOD, the private sector, and foreign governments. In 1989, the Laboratory has approximately 3,000 scientists, engineers and support staff with an annual operating budget of approximately $250 million. Nearly 40 percent of this effort is devoted to a variety of environmental and waste management programs relating to radioactive and hazardous chemical wastes, acid rain, global environmental change, and indoor air pollution (radon).

At Hanford, PNL performs the independent environmental monitoring function which requires a capability to monitor and analyze myriad samples and data and to predict the behavior of these samples in the environment. This program requires the development of computer models and state-of-the-art analytical equipment for sampling the air, surface, water, soil, vegetation, and underground environments to determine the adverse impacts, if any, of Hanford's operations on the surrounding environment. PNL also has one of the most comprehensive health physics capabilities within the DOE system. We have developed state-of-the-art dosimetry devices for measuring radiation from all sources, whether it be from natural background sources or man-made isotopes.

In addition to the multidisciplinary capabilities required to conduct the environmental research programs cited above, PNL operates a marine research laboratory, which is located on Puget Sound and the Olympic Peninsula. Possessing the only instrumented aircraft dedicated to atmospheric research in the DOE laboratory system has enabled PNL to be in the forefront of research programs dealing with acid rain precipitation and global environmental change. We also manage the Arid Lands Ecology reserve, a pristine research station in the arid climate of Eastern Washington, and DOE's National Environmental Research Park at Hanford. Thus, environmental research for a variety of applications is one of PNL's strongest capabilities.

From its earliest days as an extension of the Hanford laboratories, PNL has also been conducting a variety of research and development programs aimed at managing the wastes generated from the nuclear fuel cycle. In fact, solidification technologies that have been developed for the Savannah River, West Valley, and Hanford wastes are based on a PNL-developed vitrification technology called borosilicate glass. We have also developed what is called the "in situ" vitrification process for solidifying hazardous wastes. This technology is in the "permitting" process by EPA; it has been demonstrated on a variety of wastes, including a Superfund site. Battelle has recently transferred this technology to a new startup company which is in the process of commercializing it for application to Superfund sites around the country.

In 1986, as part of the reauthorization of Superfund legislation (SARA), the Pacific Northwest Hazardous Research, Development and Demonstration Center was established at Battelle. To be funded equally by EPA and DOE, this Center has as its mission the development of new technologies for near-term application to hazardous waste sites around the country. Unfortunately, neither agency has ever requested the necessary resources from Congress to support this Center.

Approximately two years ago, PNL proposed a new research program to the Office of Health and Environmental Research that focused on subsurface behavior of contaminants. The objective of this research was to develop the scientific and technological foundation to enable DOE to assess its underground contamination problems and to conceptualize and develop innovative technologies to isolate, immobilize and destroy wastes that are already underground. Funding for this program is contained in the FY 1989 budget.

When the Department of Energy recently conducted a comprehensive review of its hazardous waste sites, the magnitude and complexity of its remediation problems became evident. The cost of remediation - GAO's estimates are over $100 billion - is unrealistic in terms of today's budget realities. It also is impractical to believe that the sheer volume of contaminated soil can be moved or excavated to "another" site. In the case of groundwater, it cannot easily be pumped or treated. Furthermore, DOE wastes are far different and more complex then the wastes generated by other operations. DOE's unique wastes include various combinations of radioactive materials, heavy metals, and organic chemicals. In some cases, even biological contaminants are involved. Therefore, it is clear that new and innovative concepts and technologies are needed to evaluate and remediate the hazardous wastes "in situ," to reduce the overall cost and health risks of a remediation program that is based primarily on the premise of digging up the contaminated soil (or pumping the water), treating it, and then transporting it to some other location for storage and long time surveillance.

Taking into account all of these factors the Department created the concept of the Environmental Research Center of Excellence. The Center would be the Department's "center" for environmental research and the development of new and innovative environmental restoration technologies that have the following objectives:

1) reduce the time and cost required to characterize DOE waste management and environmental restoration problems and assess future alternative actions;
2) reduce time and cost to remediate the waste sites and inactive facilities at DOE installation across the nation; and
3) increase the legal and regulatory defensibility of the remediation technology chosen for any given site.

Within the FY 1990 budget for Environmental Research there is $6.0 million ($4.2M Operating and $1.8M Capital Equipment) for this program.

The FY 1990 budget request, if approved, would be allocated to research on understanding fundamental physical, chemical, and biological processes in the underground environment; developing new and sophisticated sampling and measurement techniques; and exploring the use of native underground microorganisms to detoxify or destroy wastes in place.

Planning for the Environmental Research Center of Excellence also assumes the development of scientific "user" facilities (available to the broader university and industrial community) to test and evaluate new measurement and sampling technologies and waste remediation techniques. These technologies would be "documented," or field tested, at the nearby Hanford site. As you know, Hanford has the largest inventory of hazardous wastes in the DOE system. Therefore, this is a natural "laboratory" to demonstrate new technologies as they are developed. Broader technology demonstrations would be accomplished in collaboration with the HAZWRAP program at Oak Ridge.

Another long-term research effort underway in the Laboratory that is currently directed toward solving the hazardous waste problem is called Vertical Integration of Science, Technology and Applications (VISTA). This program has as its initial goal the development of a software-based information system to guide the assessment and remediation process for hazardous waste sites at DOE facilities. The information system will link users (DOE, laboratories, remediation contractors) to computer models and technical data available at PNL in order to speed up the remediation process, thereby decreasing costs and accelerating the deployment of new technologies.

In summary, the environmental problems facing us as a nation are staggering. The Superfund program is one example; the federal government's environmental remediation program for federal lands is another. Nevertheless, the challenge for all of us is to proceed in an expeditious and cost effective manner with the task of remediation. The Pacific Northwest Laboratory has a long history of conducting research and development programs that are directed toward solving national environmental problems. The Environmental Research Center of

Excellence is an important evolution of our past role that will be very important to DOE and the entire country in our attempt to address today's environmental problems.

Battelle

William R. Wiley

Dr. William R. Wiley, Director of Battelle's Pacific Northwest Division, is a Vice President of Battelle Memorial Institute—an independent, worldwide, science-based organization dedicated to "putting technology to work."

As the principal Battelle executive in the Northwest, he is director of the U.S. Department of Energy's Pacific Northwest Laboratory, a multiprogram national laboratory operated by Battelle since 1965.

Dr. Wiley is responsible for Battelle business activities in the Northwest, including research, development and technology commercialization at Battelle's research complex in Richland, the Marine Sciences Laboratory at Sequim, and the Battelle Seattle Research Center.

A member of the Battelle staff since 1965, Dr. Wiley served as Director of Research at the Richland laboratories between 1979 and 1984. Earlier assignments include management positions with the Biology Department and the Cellular and Molecular Biology research section.

Dr. Wiley earned a bachelor's degree in chemistry from Tougaloo College, Mississippi. Studying under a Rockefeller Foundation scholarship, he earned a master's degree in microbiology from the University of Illinois-Urbana in 1960. His doctorate in bacteriology was awarded by Washington State University, Pullman, in 1965.

Dr. Wiley is a member of the Washington State University Board of Regents and is a trustee for Tuskegee University's Carver Research Foundation and the Washington State University Foundation. He is a former member of the board of trustees for Gonzaga University and has served on the Advisory Committee for Advanced Studies in Biomedical Science at the University of Washington. He is also a former member *of the Washington State Commission for the* Humanities and the Washington State Higher Education Coordinating Board.

Dr. Wiley has served as a George Washington Carver Lecturer at Tuskegee Institute, Alabama, and he lectures at black universities as part of the Black Executive Exchange Program. He holds an adjunct faculty appointment with Washington State University as an associate professor of microbiology.

Dr. Wiley is a Foundation Associate of Seattle's Pacific Science Center and was a founding member of the advisory committee for the Tri-Cities University Center in Richland, Washington. He is on the advisory board of the University of Washington's Mathematics, Engineering and Science Achievement program, and he was a member of the 1988 Energy Research Advisory Board Technology Utilization task force.

He is a member of the American Society of Biological Chemists, the American Society of Microbiology, the American Association for the Advancement of Science, and the Society for Experimental Biology and Medicine.

Dr. Wiley is a member of the boards of directors of the Washington Economic Development Partnership and the Tri-City Industrial Development Council. He has accepted leadership roles with the United Way of Benton-Franklin counties and the Mid-Columbia U.S. Savings Bonds campaign.

Dr. Wiley is listed in *Who's Who in America* and *American Men and Women in Science*. He has authored or co-authored journal articles in the fields of molecular biology and microbiology research. In 1988, he received an honorary Doctor of Laws degree from Gonzaga University. He is also a recipient of the Washington State University Alumni Achievement Award.

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Mr. SCHEUER. Thank you very much, Dr. Wiley.

I'm going to as the remaining three witnesses to try and hew to the 5-minute standard, we are running very late.

Dr. WILEY. I'm sorry, Mr. Chairman. I didn't read my watch correctly.

Mr. SCHEUER. That's all right. It's okay. We appreciate your testimony.

All right. Dr. John T. Whetten, Associate Director of the Los Alamos National Laboratory.

I know your Congressman, Bill Richardson, was keen to introduce you, Dr. Whetten, but he was unable to make it, so I will ask him to put something in the record.

Please proceed for five minutes.

Dr. WHETTEN. Thank you very much. And I do appreciate your invitation to discuss the capabilities of Los Alamos National Laboratory that could be focused on environmental research and technology development to help solve some of these problems that have been discussed today.

I want to emphasize in my discussion activities that could be used to reduce the cost, accelerate the schedule for cleanup, and to do a more effective job of cleaning up. Surprisingly, many of the major problems associated with the nuclear weapons complex do not involve radiation or radioactive materials, but rather involve non-nuclear and hazardous and toxic wastes. Thus technologies developed for the DOE sites could have a much broader application outside the DOE, such as the Department of Defense and the U.S. private sector. This greatly strengthens the need for a dedicated applied research program in support of compliance with environmental regulations, cleanup of contaminated sites and reduction of hazardous waste generation.

I want to comment on why I think the national laboratories must be involved, and I'll give really three reasons.

One is that the national laboratories, especially the weapons labs—Los Alamos, Livermore and Sandia—have a strong record of accomplishment in taking ideas from the research stage through to the engineering and systems studies to approve a product. In the nuclear weapons arena, for example, we have research-to-retirement responsibilities which have served the country's defense needs very well over the last 45 years.

Secondly, a large share of the country's most talented scientists and engineers who are used to doing interdisciplinary activities in the environmental sciences are at the national laboratories. For example, we are exceedingly good at designing and making instrumentation; developing technologies for interrogating the interior of the earth, beneath the surface; computer modeling of atmospheric and solid earth processes and working with plasmas, lasers and biologic agents.

And, finally, as my colleague Dr. Wiley has suggested, we can be viewed, really, as a microcosm of the entire nuclear weapons complex with respect to environmental restoration needs in the sense that we have problems at our laboratory sites that are similar to those facing the entire nuclear weapons complex, but generally of a much smaller scale. Therefore, we envision a program where the laboratories in concert with industry develop new technologies and apply those technologies in pilot programs at laboratory sites.

Having mentioned private industry, let me comment on what I think is the proper role of the national laboratories in relation to both industry and universities. If you look at table 1 in my written statement, which is on the next to the last page, I have shown four different aspects of environmental cleanup: basic research, technology development, technology demonstration, and the cleanup itself.

I believe the laboratories should be involved in all of these aspects but to different degrees. They should have a lead role in technology development and technology demonstration. Universities should play a key role in basic research and industry should take the lead in the actual cleanup. Laboratory involvement should decrease as technologies are developed and satisfactorily demonstrated, and the industrial activities should increase.

Now, to mention a few technologies. The last page of my written statement, which is labeled table 2, shows the list of technologies, indicated by asterisks, developed at Los Alamos National Laboratory that are either ready or nearly ready for application. It also shows many of the R&D programs in which we are now engaged, which we hope will soon lead to new technologies.

Some of the technologies are described in the text but I just briefly want to mention four this afternoon.

First is what we call supercritical water. This technology promises a capability to effectively solve problems associated with contaminated groundwater, waste streams, wastewater and waste sites. Water, it turns out, when heated to high temperatures and pressures is a very efficient oxidizer of organic materials and quickly converts even the most toxic of them to harmless carbon dioxide in water. This technology is now moving into the pilot stage and discussions are under way with potential industrial partners.

I would like to also mention an instrument that we are calling a midget mass spectrometer, and this is the heart of it that I am showing you now. This small, cylindrical object is what is called an ion trap, and what it does is to replace a huge magnet that perhaps weighs on the order of a ton. This is to allow us to do chemical analyses in situ in the field. Right now, to do chemical analyses, they must generally be done in a chemistry lab which involves weeks of time and up to several thousand dollars of expense. This is something that is portable, it can be taken into the field and measurements can be made in about 20 minutes. This kind of miniaturization and adaptation of technologies that are already developed into spinoff technologies in the environmental area, I think, promises a great deal.

My—Mike Burger, behind me, will hold up now a picture of a common native plant in the United States which is called the jimsonweed. This jimsonweed, previously thought of as pretty much of a nuisance kind of plant, has a rather unique capability we have discovered and it is able to absorb toxic metals within its structure. We have tested it for cadmium, barium, plutonium, and even explosives, and have found that it is able to suck up these materials, make them into a solid, and in the case of the explosives it makes them no longer harmful.

This small vial contains cells of this jimsonweed plant. This one which is a slightly pinkish color contains barium and a couple of explosives in very dilute quantities, which in larger quantities and larger concentrations could be very harmful. After mixing the plant cultures with the contaminated solution and then filtering the result, you get this, which turns out to be—even by EPA standards—drinkable water. The explosives are completely gone and the barium is reduced to about one part per million; formerly, it was about 200 parts per million. This is in about four hours.

And I think this is a partial answer to your question about biotechnology and the usefulness of plant materials in cleaning up harmful areas.

Finally, I would mention that we have done some work with waste sites and waste closures. This is a picture of a model waste closure system that we have developed, specifically designed to prevent contamination of groundwater by means of a liner beneath it and to prevent the intrusion of burrowing organisms and plants which could then release the waste material into the atmosphere. This is done by means of a wick on top, which is actually gravel material which removes the infiltration of water from the surface and diverts it to the side. This is what one of our pilot waste sites look like applying the gravel wick material. This is being applied now not only in Los Alamos, but demonstrations of this are planned in Utah and in Indiana.

I would close by mentioning simply that I think the national laboratories can play a role also in the larger question of the modernization of DOE facilities. If these DOE nuclear weapons complex is to be modernized, I think that laboratories like Los Alamos can play an important role. If, for example, we decide to build a new Rocky Flats production plant because of urban encroachment into that area, there is no organization that knows more about plutonium processing than Los Alamos, and the capability to design a new plant with the new materials, with new production capability designed in a modern way, is something that I think we really ought to look towards utilizing the national laboratories for as we modernize the production complex.

We think that the national laboratories can play an important role in the modernization question, also in the overall environmental cleanup, and look forward to working with the Department in developing new technologies. Thank you very much.

[The prepared statement of Dr. Whetten follows:]

United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Natural Resources, Agriculture Research and Environment

New Technologies for Environmental Cleanup of the DOE Nuclear Weapons Complex

Statement by
John T. Whetten, Associate Director
Los Alamos National Laboratory
April 27, 1989

INTRODUCTION

I appreciate the Subcommittee's invitation to discuss the capabilities of Los Alamos National Laboratory that can be focused on environmental research and technology development to help solve environmental problems at the U.S. Department of Energy (DOE) facilities.

I will emphasize activities that could be used to reduce the cost and accelerate the schedule of assessment and elimination of environmental hazards in the Department's nuclear weapons complex. Surprisingly, many of the major problems associated with the nuclear weapons complex do not involve radiation or radioactive materials but rather involve non-nuclear hazardous and toxic wastes. These problems are not unlike those faced by the Department of Defense (DoD) and by segments of United States industry.

Thus, technologies developed for the DOE sites could have much broader application outside the DOE. This greatly strengthens the need for a dedicated applied research program in support of compliance with environmental regulations, cleanup of contaminated sites, and reduction of hazardous waste generation. Such a program could reduce costs, reduce the time span for cleanup, and encourage greater effectiveness in meeting environmental compliance goals.

Let me cite an example. Current methods for analyzing field samples of volatile organic compounds are tied to analyses performed in a chemistry laboratory. Complete laboratory analyses may take two to six weeks, and if results indicate a need for more samples, the field crew must be reassembled and the collection and analytical procedures repeated. In order to speed up the process and make it much cheaper, we have developed a "midget mass spectrometer" that will allow field analysis of volatile organic compounds in air, water, and soils, with results in about 20 minutes. We estimate a 50% reduction in analytical costs using this new technology.

The three nuclear weapons laboratories--Los Alamos National Laboratory, Lawrence Livermore National Laboratory, and Sandia National Laboratories--can be viewed as a microcosm of the entire nuclear weapons complex with respect to environmental restoration needs. For a variety of reasons, these laboratories have problems similar to those facing the entire nuclear weapons complex, but generally on a smaller scale. Therefore, I envision a program where laboratories, in concert with industry, develop new technologies and apply those technologies in pilot programs at laboratory sites. Industry would then be in a position to use the new technologies to address larger problems at other DOE, DoD, and civilian sites.

The DOE national laboratories have a long history of interdisciplinary technology development in defense technologies (especially regarding nuclear weapons), energy technologies, and basic research. Let me tell you about some activities at Los Alamos National Laboratory that are appropriate to an initiative in environmental research applications.

LOS ALAMOS NATIONAL LABORATORY

The Los Alamos National Laboratory is operated by the University of California for the DOE. As stated by the Laboratory's Director, S. S. Hecker, "The Laboratory (is) a national resource in science and technology. We must strive for unquestionable excellence and be prepared to solve problems of great national importance. Our goal is to do state-of-the-art technology that is responsive to the programs important to the DOE and the nation."

Los Alamos maintains an environmental and geoscience research capability in support of national security programs. Since its inception in World War II, the Laboratory has played a key role in developing the technology base necessary to ensure our nation's nuclear deterrent. As one of the two centers of nuclear weapons design, the Laboratory originally developed its environmental program to ensure the health and safety of its workers. Simultaneously, the Laboratory developed its geosciences capability to ensure containment of underground nuclear tests. Support of nuclear weapons tests remains a primary mission of the Laboratory's environmental scientists and geoscientists today, but research is ongoing in other areas related to our national security. Our environmental scientists are increasingly involved in research to treat, characterize, and predict the behavior of hazardous and radioactive wastes.

Environmental research at Los Alamos began as part of early studies on the disposition of radioactive materials associated with the Laboratory's nuclear weapons research programs. Initial studies of the potential for ground water contamination beneath the Laboratory resulted in collaborations with the U.S. Geological Survey and the U.S. Public Health Service. The technology development for decontamination of liquid, low-level radioactive wastes started in 1953 and has continued since then. The Laboratory has also developed programs to predict the atmospheric behavior of radionuclides from atmospheric nuclear weapons testing.

The increased emphasis on environmental issues in the late 1960s and early 1970s led the Laboratory to expand research efforts in radioactive waste management. The Laboratory participated in the Nevada Applied Ecology Project that was sponsored by the DOE and combined the talents of scientists from the University of California, the Desert Research Institute, Lawrence Livermore National Laboratory, Pacific Northwest Laboratory, the Environmental Protection Agency, and the DOE. Other activities related to environmental protection include research on low-level radioactive wastes, the Yucca Mountain high-level radioactive waste project, management of hazardous wastes, and the study of responses of Western United States ecosystems to environmental stress.

Solid-earth geosciences research began in earnest at Los Alamos as a result of the Limited Test Ban Treaty signed in 1963. Before that time, atmospheric nuclear weapons testing had required capabilities in atmospheric sampling, analysis, and modeling. The 1963 treaty stipulated that all nuclear tests be carried out underground and that no radioactive debris be allowed to escape from the test area. A major investment in geological characterization and hydrodynamic modeling was necessary to ensure that all tests were "contained."

The scope of geoscience activities broadened in the early 1970s, when Los Alamos scientists and engineers originated, developed, and engineered the hot dry rock geothermal energy concept. The process is designed to extract thermal energy on a large scale from the hot but impermeable rock that underlies much of the United States and other continental land masses.

In the late 1970s Laboratory geoscientists further broadened their efforts by assisting the DOE, the U.S. Geological Survey, and other DOE laboratories in evaluating the Yucca Mountain area of the Nevada Test Site as a candidate for an underground repository for high-level nuclear waste. During the same period, Los Alamos collaborated with other national laboratories in the National Uranium Resources Evaluation Program to collect, analyze, and interpret hundreds of thousands of water and stream sediment samples taken from the western third of the United States.

This brief summary demonstrates that Los Alamos National Laboratory has many skills appropriate to solving the DOE environmental compliance and cleanup problems.

THE PROBLEM: ENVIRONMENTAL CONTAMINATION AT DOE NUCLEAR WEAPONS COMPLEX SITES

The environmental problems at the DOE Nuclear Weapons Complex have received much public attention and are of such severity that corrective action must be taken. One problem relates to past operations and inactive waste sites; a second problem concerns corrective actions needed to assure that active DOE operating facilities and waste management operations meet current compliance requirements. Some examples of environmental problems identified by DOE are

- Potential offsite contamination by volatile organic compounds in ground water used for livestock and irrigation (Rocky Flats, Colorado),
- Potential aquifer contamination by solvent and gasoline spills (Pantex, Texas),
- Volatile organic compounds in ground water (Livermore, California),
- Mercury contamination and waste sites containing uranium, organics, and metal ions (Oak Ridge, Tennessee),
- Potential ground water contamination by organic compounds (Idaho National Engineering Laboratory, Idaho),
- Potential ground water contamination by organic solvents (Sandia, New Mexico), and
- Potentially explosive material in waste sites (Los Alamos, New Mexico).

Existing cost estimates for cleanup activities are very high. This cost has prompted the Secretary of Energy to begin to formulate a five-year plan that not only aggressively addresses the remediation of environmental concerns related to waste management operations and inactive waste site cleanup, but, at the same time, includes a vigorous research program to do the job quicker, cheaper, and more effectively.

The DOE's research program will focus on the following goals:

- Minimize waste in current production,
- Reduce the current environmental and health hazards through development of technologies to neutralize in situ the toxic components of the existing contaminated sites,

- Develop robotic applied technologies to reduce the potential hazard, and
- Explore technologies used in the fields of oil and gas exploration, chemical and laser separation, radio-frequency heating, and directly-coupled plasma melting of soil.

A PROPOSED APPROACH

We propose a vigorous and innovative program in support of the Secretary's environmental cleanup program. The magnitude and importance of the environmental problems of the DOE facilities require that we concentrate the resources necessary to develop efficient and effective solutions in a timely manner. Any optimal solution must use the strengths of our universities, national laboratories, government entities, and private industry. Further, it is important that we balance basic research, applied research and development (R&D), technology development, technology demonstration, and actual cleanup for effective use of resources. We propose the approach described in Table 1, which summarizes how activities relate to environmental problems and how various organizations interface in contributing to solutions.

By performing approximately 60% of all basic research, universities are the greatest contributors to the basic knowledge pool for this nation's science and technology. Our national laboratories support basic research, applied research, and exploratory R&D in support of technology development and demonstration. Further, the laboratories have excellent research facilities for supporting collaborative activities with both universities and industry. Industry will provide the bulk of the cleanup effort. Therefore, it is important that new technologies flowing from the universities and laboratories be expeditiously transferred to industry for full-scale use. Various government organizations will contribute by funding research and exploratory R&D and by approving the use of new technologies. Working together, all of these organizations can reduce the time and cost required for cleanup and ensure more effective compliance with environmental goals.

As outlined in Table 1, we feel the national laboratories should take a significant leadership responsibility beyond the R&D phases of solving environmental problems. The laboratories could lead the technology demonstration phase with close industry collaboration. The DOE sites should qualify as excellent test beds for demonstrations because their environmental restoration sites are representative of those encountered in DoD and industry. During final cleanup by industry, the laboratories would provide oversight and monitoring in order to have continuous independent evaluations of new technologies. The mechanism we propose for Los Alamos and other laboratories is similar to the research-to-retirement role we provide in the nuclear weapons program.

The three nuclear weapons laboratories--Los Alamos National Laboratory, Sandia National Laboratories, and Lawrence Livermore National Laboratory--can provide the research-to-retirement role. Oak Ridge National Laboratory, Pacific Northwest Laboratory, and Idaho National Engineering Laboratory also have significant experience in environmental R&D. Each of these laboratories could take the lead in areas that most affect their own sites. The DOE field offices would oversee their involvement.

Two examples illustrate possible areas of collaboration between the laboratories and industry. First, it is estimated that it will require 30 years for ground water cleanup at some DOE sites. But if technologies such as the underground blocking of flow used by the petroleum industry can be developed for application to chemicals, the ground water contamination zone can be limited and the time required for corrective action can be shortened significantly.

Second, effectiveness of technologies for cleanup and compliance is another area needing development. Technologies used for waste treatment or cleanup should not generate a new waste for another environmental media or another hazardous waste form. At Los Alamos we are performing R&D for the DOE and U.S. Air Force on the use of supercritical water as a potential treatment system for explosives and other organic compounds. The attractiveness of the technology is the completeness of destruction of the compounds.

After developing a technology such as supercritical water through the demonstration phase, the Los Alamos National Laboratory must work with industry in the transfer of the technology. Industrial firms are natural collaborators with the national laboratories for addressing the cleanup and compliance needs of DOE facilities. Their involvement at appropriate phases of technology development will accelerate the application of new techniques. Transfer of the Laboratory's technology to industry can take place through the formation of negotiated partnerships at any one of several steps, from the initial research to the final distribution of a technology.

WHAT LOS ALAMOS CAN DO TO HELP

As a result of past and present R&D programs dealing with environmental problems, Los Alamos can provide relevant expertise, technology, and independent evaluations for environmental problems related to

- Assessment and monitoring and
- Fluid and solid waste cleanup.

A listing of available technologies and R&D programs related to these areas is shown on Table 2. Brief descriptions of the technologies follow.

ASSESSMENT AND MONITORING

Assessment and monitoring are key activities that are necessary for reducing and eliminating contaminants. Los Alamos has a long tradition in the development of instrumentation and computer models that support these efforts. For example, the previously mentioned midget mass spectrometer is an instrument that will be used for characterization of chemicals in ground water and at waste sites. In situ measurements and analyses will reduce the costs of site characterization activities.

Advanced drilling techniques and supporting tomography, fluid sampling tools, tracers, and borehole geophysics--all developed in support of our energy and national security programs--can be used in the assessment and in monitoring for ground water contamination and active and inactive waste sites. The Laboratory's research in fiber optics also has potential payoff in site evaluations.

These technologies provide data that can be used in three-dimensional, two-phase computer models in geologic media to reconstruct subsurface structure. Modeling can be used to determine the sorptive characteristics of waste sites and their effect on long-term migration of pollutants, to analyze site properties, and to recommend remedial actions. Modeling methods for the transport of tracers, organics, metals, and radionuclides in geologic media have been developed at Los Alamos. Some of these models include vapor migration of organic compounds with the driving forces of precipitation. Models have also been developed for risk and health assessment.

Similarly, Los Alamos has developed instrumentation and modeling techniques to assess and monitor air pollution. These advanced technologies were developed in support of the DOE's oil shale, treaty verification, geothermal energy, and air quality research programs. We also continuously monitor our operations to ensure that the Laboratory complies with federal and state regulations. In addition, the Laboratory was a major participant in the Four Corners' Air Quality Assessment program. From these activities, we have developed sophisticated instrumentation for laser diagnostics and air sampling. When coupled with computer simulations that include regional pollution and complex terrain effects models, the instrumentation can be used in the evaluation of atmospheric pollution. With additional research, we believe that better chemistry algorithms can be added for more complete models.

Los Alamos is nationally and internationally recognized in atmospheric modeling to the extent that we have been asked by the U.S. Embassy in Mexico and representatives of the Mexican Petroleum Institute to develop a joint proposal to monitor and assess the air quality in Mexico City as a prelude to remediation programs there. Finally, additional research could make satellite instrumentation originally developed for treaty verification and atmospheric research useful in determining the extent of pollution.

A potentially high-payoff research activity for both industrial and government sites is waste-stream minimization. The DOE is initiating a modernization program for the nuclear weapons complex to enhance environmental compliance, safety, and health, and Los Alamos is performing research in laser diagnostics, nuclear instrumentation, waste separation, expert systems, and process engineering targeted towards waste-stream minimization for existing and future facilities. For example, we have developed plutonium processing techniques that minimize the amount of waste generated and that recover waste from processing. The new technology is being installed at the DOE facility at Rocky Flats, Colorado. Costs are significantly reduced by using these technologies and by efficiently recovering plutonium waste.

The same instruments and computer models developed for site characterization can be used to assess compliance of cleaned-up sites with existing regulations and DOE orders. These monitoring and assessment techniques can be designed for independent confirmation that the cleanup effort has been successful. In addition, these technologies can be used to assess long-term stability of remedial measures and to recommend measures for long-term follow-up. When an emergency arises, the same tools can be used to track plumes of material and guide the response.

TECHNOLOGIES FOR FLUID AND SOLID WASTE CLEANUP

More research and technology development needs to be done to develop low-cost, reliable, and effective methods for decontaminating or destroying fluids and solids contaminated by hazardous, toxic, and radioactive materials. Storage of contaminated liquids and solids is becoming prohibitively expensive, and altogether too often, contaminated sites are paved over or dug up and moved elsewhere to become someone else's problem. Los Alamos is performing research in several of the areas outlined by Secretary Watkins. These include waste minimization through volume reduction, process chemistry and engineering; biotechnology applied to bioremediation and bioengineering, chemical extraction and destruction; decontamination, destruction and decommissioning chemistry; and the use of enhanced oil extraction technologies, coupled radio-frequency plasmas, and oxidation in supercritical water for waste destruction.

Biotechnology, Bioengineering, and Bioremediation

Through genetic engineering techniques, Los Alamos has been developing bacterial and plant cultures for application to contaminated ground water, wastewater, and waste sites. We have developed bacteria that are effective for degradation of explosives and organic chemicals. Rather than move large quantities of contaminated soils, we are developing specifically tailored bacteria that allow in situ cleanup of contaminated water and soils.

In the western United States, we have a common native plant that when consumed by animals, causes aberrant behavior. In large amounts the plant is lethal to animals. This plant (Datura innoxia) is known by the common name "jimsonweed." The production of alkaloid compounds, secondary products produced by the plants, is responsible for toxicity. Some of these plants were found growing in soil containing normally toxic concentrations of certain heavy metals. The ability to grow in soils containing toxic metals is related to the production of another set of secondary products that tightly bind the toxic metal ions. Our researchers have been able to generate metal-resistant cultures of cells derived from these plants. Some of these cultures have been selected for resistance to toxic heavy metals. These cultures concentrate cadmium inside the cells when grown in the presence of this toxic element. Moreover, exposure of cells to solutions containing barium and plutonium results in a rapid removal of these metals from solution as they are bound tightly to the cell wall. In addition, these cultures also remove explosive compounds from the same solutions and may degrade these. Plant cultures therefore have the potential for decontaminating ground water, wastewater and waste sites, and possibly can be used in waste-stream minimization. The plant cells grow rapidly and are inexpensive to produce. The cells can be concentrated in a small pellet and the metals recycled or permanently fixed for disposal. Los Alamos is presently developing engineering systems using plant cultures for waste cleanup.

Chemical Techniques

Los Alamos is developing technology for the use of supercritical water to destroy organic chemicals in aqueous waste streams with degradation products of carbon dioxide, and water. This technology promises to provide federal and industrial facilities with a capability to effectively solve problems associated with contaminated ground water, waste streams, wastewater and waste sites. Water becomes supercritical when heated to a temperature of 370°C at a pressure of 3500 pounds per square inch. In this phase, the gaseous and liquid phases become indistinguishable. Supercritical water becomes a catalyst for efficient oxidation of organic materials to carbon dioxide and water. A side benefit is that solids are apparently precipitated out of solution. This technology is moving into the pilot stage and discussions are under way with potential industrial partners. The technology is of interest to the DOE and the DoD for destruction of dilute liquid and solid organic wastes in ground water, wastewater, waste sites, and waste-stream minimization. We are also developing chemical agents that can be efficiently used for the removal of radioactive and chemical wastes in materials processing.

For many years, we have had a unique capability in the production, characterization, and use of labeled isotopes and heavy methane for monitoring and modeling atmospheric chemistry. With further research, these materials could be developed for use in resolving problems in atmospheric pollution and waste-stream minimization. These materials were used to demonstrate the "hole" in the ozone layer in Antarctica and have potential use in evaluating the importance of the so-called greenhouse gases.

Plasma Destruction

A technology using directly coupled radio-frequency plasma destruction of acutely toxic organic chemicals containing chlorine or bromine is being investigated at the Laboratory. Although alternative methods of plasma destruction are available, the use of arc-electrode or magnetohydrodynamic (MHD) generated plasmas results in the incineration occurring at temperatures much lower than the 10,000°K temperature available in plasmas, with subsequent incomplete destruction of the waste. Furthermore, contamination from the electrode material or MHD-generated plasma can add to the waste stream. The Los Alamos approach is to use a radio-frequency generated plasma. In this technology, the waste material becomes the "catalyst" for creating the plasma with total destruction occurring at 10,000°K with no externally added materials. This destruction results in complete atomization of the waste with no added contaminants. This ability to attain high temperatures of plasmas has potential for total destruction of materials such as dioxins and other highly toxic materials that may occur in ground water, wastewater, waste sites, and in waste streams.

Oil and Gas Exploration and Recovery Techniques

Enhanced oil recovery (EOR) technologies from the petroleum industry have potential application to hazardous waste problems. Los Alamos is exploring use of EOR methods to isolate and cleanup *in situ* underground plumes of hazardous materials. These technologies can be applied to contaminated ground water as well as inactive waste sites. In addition, several of the techniques used underground for petroleum recovery or mining should apply to removal of underground contaminants. We are collaborating with universities and working with industry in this technology.

In many cases of soil contamination, the organic compound is bound so tightly to the soil that conventional "air stripping" techniques will not work. Heat pipes, originally patented at Los Alamos in 1965, are a potentially efficient means of delivering energy to volatilize the organic waste so that air stripping becomes viable. Los Alamos is an international leader in heat pipe technology and is interested in the development of heat pipes for volatilization of organics for efficient cleanup.

Closure Technologies

Using natural materials, Los Alamos has developed a technology for closure of hazardous waste and low-level waste sites. The technology is presently being demonstrated at Los Alamos, and other demonstrations of the technology, funded by the DoD, are in planning stages for sites in Utah and Indiana. The purpose of these technologies is to secure a waste site and prevent roots and burrowing animals from intruding into waste material and to prevent ground water contamination.

Incinerator technology using advanced air cleaning technology has been developed at Los Alamos for polychlorinated buphenyls (PCBs) and "mixed" hazardous and radioactive wastes. We have designed and constructed the only licensed incinerator technology for mixed wastes. We have also developed a mobile incinerator for the U.S. Navy for the destruction of flares. Incinerator technology for the destruction of hazardous materials in cleanup wastes is currently being explored. This technology can be applied to minimization of waste streams and the storage of wastes at waste sites.

ENVIRONMENTAL COMPONENT OF MODERNIZATION ACTIVITIES

Environmental protection and waste minimization are major concerns in modernizing the nuclear weapons complex, and the estimated cost for environmental matters is a substantial fraction of the total cost of the modernization program. The treatment, storage, and disposal of solid and liquid waste are overwhelming environmental problems. In addition to producing toxic wastes and pollutants like industrial facilities, DOE facilities generate large amounts of radioactive waste. This waste includes materials contaminated with small amounts of radioactivity, such as cleaning rags, as well as liquid and metal residues from production processes.

The Secretary of Energy's modernization program will optimize the nuclear weapons complex facilities and operations with regard to production, cost, and minimization of waste streams and will enhance safety and health. In the interim, upgrades to operating facilities are required. An essential component of the modernization and upgrade program is the development of new nuclear weapon production technologies that are not only optimized for cost and production but also for minimum waste and ensured safety. The national laboratories have a 45-year history of developing enabling technologies for nuclear weapons production. Thus, they have the necessary integrated R&D capabilities that can be used to develop the new, optimized production technologies.

Los Alamos is currently developing several technologies for enhancing environmental protection and minimizing waste in the modernization program. Many of the technologies that are developed for waste cleanup will have direct application in modernization. Laser diagnostics can be used for real-time measurement of process systems, incinerator performance, and the chemistry associated with other high-temperature processes. Instrumentation and modeling can be used in assuring that new facility siting plans meet current and projected regulatory requirements and for characterizing proposed sites. They can also be used for monitoring at new and existing facilities. We have developed a computer model that simulates material flow throughout the production complex. The addition of expert systems and systems engineering would provide the capability of optimization of material flow with concurrent minimization of wastes. For chemical processes, Los Alamos has the only Cray computer version of the ASPEN code, which is a chemical process simulation program that includes economics. These capabilities can be used to evaluate and recommend alternate technologies for waste minimization during the conceptual design of new facilities and at existing facilities.

An added capability that needs R&D expansion is the understanding of the health risks associated with the presence of environmental contamination. Risk assessment plays an important role in selection of alternative methods of cleanup, the determination of "how clean is clean," and the final decisions about future use of a site after remedial action. Public understanding of the risks associated with alternatives for cleanup of a site or the decision to fix-in-place is key to rapid and economical solutions to environmental contamination. Potential health effects resulting from the proposed remedial actions must be explained with minimum uncertainty. The R&D for health effects determination should be a partnership between the universities and national laboratories. The DOE Office of Health and Environmental Research is a recommended sponsor for this type of R&D.

CONCLUSIONS

The cleanup of the radioactive and hazardous waste accumulated at the various DOE sites over the past 45 years presents a scientific and technological challenge. Further, the effort is projected to cost billions of dollars over the next 20 to 30 years. I have used the considerable and relevant capabilities resident at Los Alamos to illustrate the potential for DOE national laboratories to be major contributors to solving these serious problems. Collaborative partnerships and consortia among our universities, national laboratories, and industries are proposed as an approach to address these problems of national importance. A strong, applied environmental R&D program can effectively use the results of basic research to develop innovative technologies for transfer to and use by the private sector. Such a program can reduce costs, decrease required cleanup times, and lead to more effective environmental protection.

In conclusion, I note that any new technologies developed for the cleanup of DOE sites will be applicable to similar and related environmental problems existing at DoD and industrial sites. Los Alamos is committed to using its personnel, experimental facilities, and other resources to assist in solving environmental problems that affect the health and security of our nation.

TABLE 1

IDEAS AND INTERFACES FOR ENVIRONMENTAL CLEANUP

	BASIC RESEARCH	TECHNOLOGY DEVELOPMENT	TECHNOLOGY DEMONSTRATION	CLEANUP
COGNIZANT DOE OFFICE	Office of Health & Environmental Research	Defense Waste Management	Defense Waste Management/ Field	Field/Defense Waste Management
PRIMARY ORGANIZATIONS	Universities & Laboratories	Laboratories supported by industry	Laboratories teamed with with industry	Industry with Laboratory oversight
ACTIVITIES (EXAMPLES)	Health effects	Ground water contamination	Cleanup demonstrations on Laboratory and other sites	Cleanup and monitoring
	Theoretical ecology	In situ neutralization of airborne constituents		
	Ecologically acceptable processing	Immobilization and neutralization of airborne constituents		
	Transport code development	Transport		
		Processing alternatives		
		Robotics		
		Risk analysis		

TABLE 2

LOS ALAMOS NATIONAL LABORATORY TECHNOLOGIES(*) AND R&D PROGRAMS THAT CAN BE APPLIED TO THE DOE NUCLEAR WEAPONS COMPLEX ENVIRONMENTAL PROBLEMS

	ANALYSIS AND ASSESSMENT		CLEANUP	
	INSTRUMENTATION	MODELING	FLUIDS TREATMENT	SOLIDS TREATMENT
GROUND WATER	* Midget Mass Spectrometer * Advanced Drilling * Tomography * Fluid Sampling Tools * Borehole Geophysics Fiber Optics Reactive Tracers	* 3-D, 2 Phase transport * Reactive Tracer Simulation * Risk Assessment * Water Chemistry Estimation	Supercritical Water Plant Cultures Bacterial Cultures EOR Technology Chemical Agents	Supercritical Water Coupled RF-Plasma Bacterial Cultures Plant Cultures Chemical Agents
ATMOSPHERIC	LIDAR * Laser Diagnostics * Air Sampling Satellite Instrumentation	* Global Circulation * Regional Pollution * Terrain Effects Atmospheric Chemistry	* Labeled Isotopes * Heavy Methane SO_2 Stack Gas Removal	* Air Cleaning * Filters
WASTEWATER	Nuclear Instrumentation * Midget Mass Spectrometer Fiber Optics	* 2 Phase Process Engineering Expert Systems	Plant Cultures Coupled RF-Plasma Supercritical Water Bacterial Cultures Chemical Agents	Plant Cultures Coupled RF-Plasma * Incineration Bacterial Cultures
INACTIVE/ACTIVE WASTE SITES	* Midget Mass Spectrometer * Advanced Drilling Tomography Ground Penetrating Radar Seismics Satellite Instrumentation Borehole Geophysics	* 3-D, 2 Phase transport * Reactive Tracer Simulation * Risk Assessment * Water Chemistry Estimation	* Incineration EOR Technologies Heat Pipe Volitization	Bacterial Cultures Plant Cultures Coupled RF-Plasma Microwave Treatment Closure Technologies * Incineration Supercritical Water
WASTE STREAM MINIMIZATION	Laser Diagnostics Nuclear Instrumentation Waste Separation	* 2 Phase Process Engineering Expert Systems	Systems Engineering * Actinide Process Chemistry	* Incineration Supercritical Water Systems Engineering * Volume Reduction

Mr. SCHEUER. Thank you very much, Dr. Whetten.

Dr. Schock?

Dr. SCHOCK. Mr. Chairman and members of the—

Mr. SCHEUER. Dr. Schock is the Program Leader for Energy of the Lawrence Livermore National Laboratory.

Dr. SCHOCK. Thank you, Mr. Chairman, and members of the subcommittee. I want to begin by thanking you on behalf of our director, John Nuckolls, for the opportunity to testify before you today regarding our research efforts in developing innovative approaches to the management of hazardous waste, and I particularly appreciate your interests, as has already been shown in this hearing, in innovative technology.

I want to emphasize, following on what Mr. Duffy said earlier, that we strongly support Secretary Watkins' policy that the environment can and must be protected while successfully completing the DOE mission. There are, of course, no simple technical solutions that will solve all of our problems, as we are all well aware. However, there is a large store of knowledge out there and this knowledge base gives us some very firm ideas about where our research needs to be focused to in fact develop these innovative technologies.

I can assure you that our laboratory takes safety and environmental issues very seriously and has done so since its inception. We have long had outstanding personnel in the diverse technologies and the sciences needed to characterize and remedy waste hazards in the environment. We were one of the first laboratories to seriously study the link between radiation and cancer, and, of course, we continue to do so today. We have made significant progress in the definition and remediation of the non-nuclear contamination that we inherited when we occupied our own site in 1952. We have also made many breakthroughs in monitoring and minimization of our own waste.

One such innovative approach to monitoring is the state-of-the-art, on-line monitoring system for the wastewater stream at our own laboratory. It simultaneously monitors the acidity of the water, the radioactivity and the metal content with three chemical detectors, each specific to a particular group of metals.

Another effort which points to minimization, this effort has resulted in a prototype cleanable prefilter. It's a reusable filter that recovers 98 percent of the radioactivity that would otherwise have to be disposed of as waste. The conventional technology is to filter out radioactivity in the air and then have to dispose of those filters as solid waste. We can get rid of 98 percent of that radioactivity.

While I cannot describe all of our capabilities today, I will just briefly in the interest of time touch on a few. In addition to the innovations that we have applied directly to our own waste, we have developed a large inventory of sophisticated technologies resulting from our work on other issues of national importance. One example is our work in developing pyrochemical processes as an alternative to aqueous chemical processes in order to minimize the waste in many parts of the nuclear fuel cycle.

In addition, the need to reduce the radiation dose to workers has led us to the development of special robotics. I think you are also aware that we are one of the lead laboratories in global climate modeling and are presently involved, with DOE funding, in doing a comparison of the existing countries' resources in global climate modeling to find out why they agree when they agree and why they disagree when they don't.

We also have the Nation's capability, called the atmospheric release and advisory capability, which is funded by the DOE, the DOD and the NRC.

At Livermore we are studying the use of microorganisms for detoxification of metals dissolved in water, and in addition we are doing research on the biodegradation of chlorinated hydrocarbons such as trichloroethylene and methylene chloride that are, as you know, very common soil and groundwater contaminants.

we also have ongoing research that has identified and now seeks to realize a microbe that will transform residual high explosive contaminants in soil into harmless byproducts. In principle, these microbes can be used either in contained surface bioreactors or pumped into the subsurface for in place soil or water remediation, similar to the techniques that are used, or are beginning to be used commonly in microbial-enhanced soil recovery.

As you know, incineration—turning to another technology—holds great promise for hazardous waste destruction. Over the years we have been developing models to study the combustion of hydrocarbons for energy programs. Basically, these are models of—they were begun as models of the combustion process inside an internal combustion engine. They are used in joint projects between our laboratory and American industry, both the auto industry and the petroleum industry. But because these models treat complex chemistry in a combustion environment, we are now using them to determine the optimum conditions of pressure, temperature and concentration that give the highest destructive efficiency for species such as the ones I already mentioned, the chlorinated hydrocarbons.

Now the traditional methods of sampling environmental contaminants often strongly perturb the groundwater system and we are all working on ways to improve that. A promised method of addressing these issues that is in use at our laboratory is the use of very thin fiber-optic cables. These optical fibers allow a single instrument on the surface to monitor multiple locations in the subsurface simultaneously and inexpensively.

We have also developed chemical sensors attached to the remote end of these optical fibers, and I've brought one of these along. So I'll be glad to pass it up to you. You can see the fiber is not very big. What we do is we place a special sensor on the end of the fiber and these allow measurements of a broad range of chemicals and their detection at very low concentrations of specific contaminants, and, in principle, will obviate the need for continued sampling and the perturbation of the groundwater by that continued sampling. The optrode itself is inside the little glass tube that will be before you shortly.

Now the modeling of inorganic chemical reactions in water, in groundwater is very advanced and we have a well-established reputation in that area. However, little is known about modeling groundwater containing both organic and inorganic chemicals, and we're presently adding an organic chemical database and when this is completed we expect to be able to apply that model to sites with mixed waste.

Another significant effort is assessment of the potential health and environmental risks associated with alternative cleanup options. The goal is improved methods and supporting data for understanding the pathways to exposure to radioactive and nonradioactive substances. For example, we are now conducting experiments to quantify the extent to which volatile organic compounds transfer from tapwater to household air, and in related work we are conducting experiments to gain a better understanding of how these volatile organic compounds are absorbed by the skin from dilute water solutions. Our efforts in this area build on our long and successful history of performing radiological dose assessments from past activities at the Nevada Test Site and in the South Pacific, particularly in the Marshall Islands, and, in fact, I might mention that we have also plants as uptake of radionucleides in the Marshall Islands, and in a recent publication we have done the risk assessment for the Chernobyl reactor accident.

Finally, we believe that many of our Nation's present waste and environmental problems stem not from ignorance, but rather from a failure to identify, integrate and apply the relevant knowledge. Reliance on incomplete assessments and a limited repertoire of standard methods has resulted in problems that could have been avoided had we taken the time to look at the entire problem. We feel that the most innovative and ultimately the most efficient and cost effective approach to hazardous waste management is to address the issue of complexity and integration concurrently with method-oriented research.

Because of this we have established a group from a cross section of our laboratory's program and discipline organizations to identify the institutional and the technical problems that need to be addressed and then to prioritize them in terms of their urgency and their difficulty. This combines one national laboratory's specialized disciplinary excellence with its expertise in the creation, management and completion of multidisciplinary programs. We believe that this approach will enable us to exploit rapidly and effectively the traditional single method, or single discipline rather, form of scientific research.

That is a very brief summary of the kinds of things we—that go on at Livermore. I have submitted for the record a more detailed bibliography and some capabilities. We are eager to participate in the Department of Energy program, and I will be pleased to answer any questions.

[The prepared statement of Dr. Schock follows:]

Statement of Dr. Robert N. Schock

Energy Program
Lawrence Livermore National Laboratory
Livermore, California 94550

before the

Subcommittee on Natural Resources, Agricultural Research, and Environment

of the

Committee on Science, Space, and Technology

April 27, 1989

Mr. Chairman and Members of the Subcommittee:

I am pleased to appear before you today to testify regarding the Lawrence Livermore National Laboratory's (LLNL) research efforts in developing innovative approaches for the management of hazardous wastes. I am the Energy Program Leader at Lawrence Livermore National Laboratory and have been asked by our Director, John Nuckolls, to represent the Laboratory. Today I will describe how Livermore is developing and applying innovative technologies to manage hazardous wastes, including radioactive wastes. We have been focusing our efforts both on our own wastes and on those of other DOE facilities. We strongly support Secretary Watkins' policy that the environment must and can be protected while successfully achieving the DOE mission.

I want to begin my testimony by observing that most of this nation's waste-related problems are very complex and involve aspects of many diverse technical fields--from chemistry and engineering through hydrogeology and atmospheric sciences, to biology and ecology. There are no simple technical solutions that will solve all of our problems. Cost-effective clean-ups and the prevention of future contamination require not only progress in many technological areas, but also both technical and managerial innovation in integrating and applying these diverse technologies.

I can assure you that our Laboratory takes safety and environmental issues very seriously and has done so since its inception. We have long had outstanding personnel in diverse technologies and the sciences to characterize and remediate waste hazards to the environment. We have made significant progress in the definition and remediation of the non-nuclear contamination inherited when we occupied' our site in 1952. We have assembled an interdisciplinary team of experts in radiation science, fire science, and industrial hygiene to develop new technology for managing hazardous materials and wastes. This team has already made breakthroughs in monitoring and minimization. One such innovative approach is the upgrade to a state-of-the-art on-line monitoring system for the waste water stream at the Laboratory. It simultaneously monitors acidity of the water, radioactivity (including the ability to identify specific isotopes), and metal content using three chemical detectors, each specific to a particular group of metals. Another effort has resulted in significant minimization of radioactive waste. A prototype cleanable pre-filter has been developed that reduces the volume of waste air filters by more than forty times while recovering 98% of the radioactivity that would otherwise be disposed as waste.

While I cannot describe all of these capabilities and accomplishments in the allotted time, I request that you enter into the record a draft report on LLNL's capabilities in this area, together with a partial listing containing about 100 out of several thousand scientific publications in or closely relevant to the environmental sciences and hazardous waste areas. Today I will discuss only a few capabilities that show significant promise of contributing to the solution of the nation's waste and environmental problems.

We believe that a requisite to remediation is the careful characterization of the nature and extent of contamination. Our soil and ground water assessments have applied advanced drilling and sampling techniques and very sensitive, state-of-the-art analytical techniques, to develop a new understanding of the behavior of sub-surface water and the contaminants that are associated with it. As a result, we have been able to convincingly describe the past source and migration of specific contaminants. Such a foundation is absolutely essential before either remediation or a finding of no significant future hazard.

In addition to innovations applied directly to our own wastes, we have developed a large inventory of sophisticated technologies resulting from our work on other issues of national importance. Much of this technology has promise for being applied either directly or with further development to the nation's waste and environmental problems, and will be the subject of my remaining testimony.

Mixed hazardous wastes containing organic and inorganic chemicals including heavy metals are common to many DOE sites. Remediation and treatment methods using highly specialized microorganisms have the potential to treat large volumes of liquid low-level waste economically and with minimal adverse effects to the environment. They can be used either in contained surface bioreactors or pumped into the subsurface for in-place soil/water remediation, similar to the techniques being intensively studied for microbial enhanced oil recovery.

At LLNL we have studied use of microorganisms for the detoxification of selenium and other compounds dissolved in water. In addition, we are doing research on the biodegradation of halogenated-hydrocarbons (such as trichloroethylene and methylene chloride) that are common soil and groundwater contaminants. We also have ongoing research to identify and utilize a microbe that will transform residual high-explosive contaminants into harmless byproducts.

Incineration holds great promise for hazardous waste destruction. For years at LLNL, we have been developing models to study combustion of hydrocarbons for energy programs. Because these models treat complex chemistry in a combustion environment, they can also determine the optimum conditions of pressure, temperature, and concentration that give the highest destructive efficiency for chlorinated hydrocarbons, a large component of hazardous waste. Our goal is to identify the critical chemical pathways that lead to maximum production of components that can be removed easily from the combustion products. This knowledge can then be translated into improved incineration technology.

Traditional methods of sampling environmental contaminants often strongly perturb the ground water system. In some cases, the sampling itself generates a waste-disposal problem. Frequently, the samples change in chemistry before they can be analyzed, even with a nearby mobile facility. A promising method of addressing these issues is the use of very thin fiber optic cables. The use of optical fibers to transmit light to and from remote locations allows optical spectroscopy to be performed in place rather than by removing samples for laboratory analysis. Optical fibers also allow a single surface instrument to monitor multiple subsurface locations simultaneously and inexpensively. We have also developed chemical sensors attached to the remote end of optical fibers (optrodes) that allow measurements of a broader range of chemicals and can be made to detect low concentrations of specific contaminants. The further development of fiber optics and optrode-based analytical techniques can result in faster and cheaper characterization of sites and monitoring of clean-up or waste-treatment processes.

As you are aware, there has been controversy regarding the ultimate cost of environmental remediation at DOE sites and the question of which sites need more immediate attention. In order to set priorities and make choices to reduce cost, there must be agreement as to the distribution and magnitude of contamination. When the contamination is underground, a large number of expensive drillholes is required. Computer models of processes in the subsurface environment can assist in reducing the number and optimizing the location of drillholes, but they must be accurate and useable.

LLNL is improving quantitative computer modeling of transport and reaction of contaminants in groundwater systems. The thrust of our modeling activities is to make technically sound predictions of the fate of hazardous and radioactive chemicals in the underground environment, both for guiding field characterization studies and for predictive safety analyses.

Existing computer models that address either fluid flow or geochemical reactions are very large and complex, but accepted by the technical community. Models that couple fluid flow and geochemical reactions are not as well accepted, largely because they typically detail one area and generalize the other, or generalize both. We are building and testing models that are coupled, yet contain sufficient detail of both chemistry of the species and physics of the flow.

In a closely related area, modeling of inorganic chemical reactions in groundwater is very advanced, and LLNL has a well-established reputation in that area. However, little is known about modeling groundwater containing both organic and inorganic chemicals. We are presently adding an organic chemical database to our very successful inorganic geochemical codes. The current geochemical code with the inorganic database can address complex mixtures involving half of the Periodic Table of Elements. When addition of the organic database is completed, this code will be applied to sites with mixed waste .

Another significant site remediation effort is assessment of potential health and environmental risks associated with alternative cleanup options. Our research in this area focuses on the development of improved methods and supporting data for calculation of exposures to radioactive and non-radioactive substances. The goal is improved understanding of essential characteristics, not a new computer methodology. For example, we are now conducting experiments to quantify the extent to which volatile organic compounds transfer from tapwater to household air. In related work, we are conducting experiments to gain better understanding of the skin uptake of volatile organic compounds from dilute water solutions. Efforts in this area build on our long and successful history of performing radiological dose assessments from past activities at the Nevada Test Site and in the South Pacific, and, in a recent publication, the Chernobyl reactor accident (Science, Vol 242, pp 1513-1519, 1988).

One of the most important aspects of health-risk assessments is the relationship between dose and biological response. We have a continuing effort to refine such relationships for both radioactive and nonradioactive substances and to explore the causes and prediction of cancer. We are also quantifying the uncertainties associated with the different components of the risk assessment process. Our ultimate goal is an integrated understanding of contaminant effects and pathways from hazardous waste sources to humans.

Many of our nation's present waste and environmental problems stem not from ignorance, but from a failure to identify, integrate, and apply the relevant knowledge. Reliance on incomplete assessments and a limited repertoire of standard methods has resulted in problems that could have been avoided. We at LLNL feel that the most innovative--and ultimately efficient and cost-effective--approach to hazardous waste management is to address the issues of complexity and integration concurrently with method-oriented research.

We have already established a Hazardous Waste Working Group consisting of senior scientists from a cross section of LLNL program and discipline organizations. The objective of this group is to identify the institutional and technical problems that need to be addressed, to prioritize them in terms of urgency and difficulty, and to develop a dynamic and interactive research program that will combine our specialized disciplinary excellence with our expertise in the creation, management, and completion of multidisciplinary programs. We believe that this innovative multidisciplinary conceptual "research" will enable us to exploit rapidly and effectively the traditional, single-discipline form of scientific research.

To summarize, at LLNL we have applied innovative technology to managing our own hazardous and radioactive wastes. We also have capabilities and ideas that we believe would apply to other sites and would be happy to participate in such programs. I will be pleased to answer any questions that you may have about my testimony, or about LLNL capabilities.

BIOGRAPHICAL INFORMATION

Robert N. Schock

Dr. Schock was born in Monticello, New York on May 25, 1939. His primary and secondary education were received in public schools and he graduated from Monticello High School.

He received a Bachelor of Science degree in geology from the Colorado College, a Master of Science degree in geochemistry and a Doctor of Philosophy in geophysics and solid-state physics from Rensselaer Polytechnic Institute.

Since receiving his Bachelor's degree, Dr. Schock has been employed as a geophysicist with Continental Oil Co., a geologist with Texaco Inc., and a research associate with the University of Chicago.

In 1968, he joined the Lawrence Livermore National Laboratory (then Lawrence Radiation Laboratory) as a senior scientist in the Chemistry Department. In 1972, he became group leader for High-Pressure Physics, in 1974, Geosciences Section Leader, and in 1976 Earth Sciences Department Head, responsible for personnel and budgets in test containment, treaty verification, oil shale, nuclear waste disposal, and basic science.

In 1987, Dr. Schock became the Laboratory's Energy Program Leader and is responsible for $30 million of research programs in nuclear waste management, fossil energy recovery, geothermal energy, combustion research, and basic energy sciences.

He is a member of the American Association for the Advancement of Science, the American Geophysical Union, and the Society of the Sigma Xi. He has been a senior Fulbright Fellow to the Federal Republic of Germany and a Visiting Research Fellow in the Institute for Advanced Studies at the Australian National University. He has served or serves on the editorial boards of numerous scientific journals and on several national scientific panels. His biography is listed in Who's Who in America.

Dr. Schock is married, has three children, and resides in Pleasanton, California.

Mr. Scheuer. Thank you very much, Dr. Schock.

Now we will hear from the last member of the panel, Dr. Tim Myrick, Manager of the Office of Waste Management Operations at the Oak Ridge National Laboratory.

Dr. Myrick?

Dr. Myrick. Thank you. Mr. Chairman and members of the subcommittee, I am currently responsible for the management of all radioactive and hazardous waste systems at Oak Ridge National Laboratory. I appear before the subcommittee not as a researcher with specific areas of technical areas to sell, but as an R&D user. I have a firsthand understanding of the need for focused R&D in the waste management and environmental restoration areas.

The work environment at Oak Ridge has provided an ideal location for developing and applying the needed R&D for remediation and waste operations technologies. That environment includes an internationally recognized laboratory at ORNL, a broad spectrum of generated wastes on which to apply those technologies, large areas of legacy waste and contaminated areas in a human Eastern environment, which is different than the environments out West, and a very complex geologic setting.

We have an extremely active commercial waste management and technical support sector in Oak Ridge, with over 36 nationally recognized firms in town. We have a well-developed university collaboration network, and we have a regulatory environment that is conducive to progress in implementing practical solutions. We also have a large government presence that is committed to the involvement of research, commercial, regulatory and university communities in the solving of waste management problems. This is the so-called DOE model concept which was born and has been implemented at Oak Ridge.

Progress has been made in numerous areas through ongoing R&D programs in Oak Ridge, particularly in the areas of in situ stabilization technologies, both chemical, ISV and particulate grouts; in hydrologic research for identification of quick and effective fixes for corrective actions; and waste minimization for both solid and liquid wastes; and low level waste disposal; and biotechnology applications in remediation; and large-scale metal decontamination; and in sludge land farming, to name a few.

Technology transfer is an extremely important aspect of those—developing those promising technologies, and again the Oak Ridge technical community has proven itself with examples such as the transfer of air-stripping technologies from Department of Defense applications through the HAZWRAP programs and to other DOD programs in remediation; the import of the tumulus technology from France, with the export of the Oak Ridge experience with that technology to other DOE sites and to the State low-level waste compacts; and the transfer of ultrasonic-based radiation survey instrumentation from ORNL to widespread commercial application.

Based on our experience in Oak Ridge, I believe that the existing technology in the remediation area nationwide is not adequate. The major problems with those existing technologies are that they do not adequately address the range of radioactive and mixed wastes and chemically hazardous wastes that are requiring treatment; that the cost of implementing those existing technologies on a large scale will be prohibitive; and that many of the current solutions really represent only interim fixes.

Considering the billions of tax dollars that may be requested for such remediation projects, it would seem prudent to plan to invest some portion of that resource into money-saving R&D programs. Areas where I feel such funds could be well spent include: biotechnologies, both in situ and in-process plant applications; in waste minimization; in dilute solutions treatment technologies; in waste mobilization technologies; in robotics and artificial intelligence; in contaminant risk evaluations; environmental characterization, including smart real-time monitors; and expanded biological monitoring programs.

Thank you, Mr. Chairman. I would like to express my appreciation for the opportunity to present my views to the subcommittee, and I would be pleased to answer any questions.

[The prepared statement of Dr. Myrick follows:]

Statement of
Tim Myrick

Program Manager
Waste Management Operations Program
Oak Ridge National Laboratory
Operated by Martin Marietta Energy Systems
for the Department of Energy
Oak Ridge, Tennessee

Before the
Natural Resources, Agriculture Research,
and Environment Subcommittee

April 27, 1989

TESTIMONY
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH, AND ENVIRONMENT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
APRIL 27, 1989

Tim Myrick
Oak Ridge National Laboratory

Mr. Chairman and Members of the Subcommittee, at the Oak Ridge National Laboratory (ORNL), I am responsible for the management of all radioactive and hazardous waste collection, treatment, storage, and disposal systems at that multi-program Laboratory. Prior to assuming this position in 1987, I served as the Manager of the ORNL Remedial Action Program. These two assignments have given me a broad look at the waste management research and development (R&D) needs in both the growing environmental restoration and waste management operations arenas. I am pleased to be given the opportunity to discuss my perception of the success and future of waste management research and development within the context of your invitation.

I appear before the Subcommittee not as a researcher with specific technical areas to sell but as a R&D user. I have a first-hand understanding of the need for focused R&D in waste management that can be brought into near-term application to solve today's problems.

My work location at one of the Department of Energy's (DOE's) major operations complexes in Oak Ridge, Tennessee, provides a unique mix of internationally recognized research facilities at ORNL, defense and enrichment plant operations with constantly changing missions, a broad spectrum of generated waste streams, large areas of legacy waste disposal and contamination, large government presence with plans for long-range modernization of major facilities, an extremely active commercial waste management and technical support sector, a well-developed university collaboration network, and a regulatory environment that is conducive to making progress and implementing practical solutions to problems. This critical mass of opportunities and capabilities has come together in a humid eastern climate and complex geologic setting that provides the ideal environment for innovation and ingenuity.

SPECIFIC R&D APPLICATIONS

I would like to briefly describe a few specific examples of the type of practical R&D applications that have come from the Oak Ridge technological team. I begin first with projects recently completed at ORNL that have impacted me personally as the beneficiary of the significant environmental and operational improvements resulting from applied R&D.

In-situ Stabilization Technologies: Contaminant releases from old waste disposal trenches are a continuing concern, particularly in humid eastern sites. In-situ stabilization of trenches with both chemical and particulate grout has been demonstrated at full scale at ORNL, with particularly impressive results for the acrylamide-based grouts. This stabilization technology, when combined with trench compaction, is now forming the backbone of site-closure planning on a large scale. Based on this success, similar grout technology applications are now being made for conducting corrective actions to limit groundwater inleakage in active waste disposal units.

Hydrologic Research to Identify Quick/Effective Actions: Watershed hydrologic analyses have been effectively used to identify major contaminant release pathways and to recommend fairly simple, effective near-term corrective actions. In one instance at the Solid Waste Storage Area (SWSA) 4 at ORNL, a straightforward, relatively inexpensive surface/groundwater diversion resulted in an almost immediate 50-percent reduction in Sr-90 discharges from that most problematic contamination source (Fig. 1). Similarly, the development of capabilities for hydrologic forecasting of watershed responses during accident scenerios has become the backbone of the ORNL emergency response team's site discharge management plan.

Waste Minimization R&D: Of particular importance to me as an operator of waste treatment and disposal systems is the effectiveness of R&D efforts on minimizing waste volumes and hazards. Waste generator process flow sheet analyses and resulting process changes on the liquid low-level radioactive waste (LLLW) system at ORNL have contributed significantly to the greater than 75-percent volume reduction in that waste stream over the past 4 years (Fig. 2). This R&D-supported waste minimization program has played a key role in reducing the vulnerabilities associated with critically short LLLW storage space at the Laboratory.

Low-Level Waste Disposal Technologies: The Oak Ridge technical community has taken a national lead in the development and demonstration of improved solid low-level radioactive waste treatment and disposal technologies. The Tumulus Disposal Demonstration is the first in the nation to demonstrate, on an operational scale, the implementation of a greater confinement disposal system for this waste type (Figs. 3 and 4). The demonstration, now entering its second year of operation, has met the goals of waste containment, operability, zero environmental release, and minimal occupational radiation exposure. The demonstration unit will be completely loaded in FY 1990 and placed under an interim cover awaiting final capping in FY 1993 (Fig. 5).

At the sister DOE facilities in Oak Ridge (the Y-12 Weapons Plant and the Oak Ridge Gaseous Diffusion Plant), similar accomplishments and R&D initiatives have been ongoing. Three examples are provided below to give the committee a flavor of some of those activities.

Biotechnology Applications in Remediation: The S-3 ponds at the Y-12 Plant, holding millions of gallons of concentrated liquid wastes containing nitrates, heavy metals, and organics, were successfully remediated utilizing a biodenitrification technology developed in Oak Ridge (Figs. 6 and 7). This technology was demonstrated for both process equipment and in-situ applications and has been utilized for other DOE applications, at Portsmouth and Fernald, Ohio, based on the success at the Y-12 Plant.

Metal Decontamination Technologies: Some 85,000 tons of uranium-contaminated metal scrap currently exist in stockpiles at ORGDP and other DOE Oak Ridge Operations (ORO) sites (Fig. 8). An initial cleanup campaign was initiated in 1983 and is now being followed by a comprehensive decontamination and recycle program to be undertaken by commercial vendors (Fig. 9). This program, based on demonstrated decontamination methods on a small scale, is scheduled to get under way later this fiscal year.

Sludge Landfarming: In cooperation with the State of Tennessee and the City of Oak Ridge, a large-scale sludge landfarming operation has been under way since 1983 on the Oak Ridge Reservation. This activity, as part of the DOE Biomass Program, is focusing on the improvement of soil fertility through waste sludge recycling. Vegetative growth response, soil nitrogen dynamics, and environmental impacts are being studied to form a data base for improving sludge disposal programs nationwide. The Oak Ridge landfarming project is unique in that the sludge contains trace levels of radionuclides, in addition to the standard metals and organic/inorganic contaminants; these trace radioactive constituents are proving to be excellent tracers for tracking contaminant movement.

TECHNOLOGY IMPORT/EXPORT

The cornerstones of the DOE Model Concept, born through the initiative of the Oak Ridge technical community, are the communications, interchange, and technology import and export between the government, commercial, university, and regulatory communities. Numerous examples abound that show the Oak Ridge commitment to this model of cooperation and team problem solving. A few of the more significant include

o the solidification of 50,000 gallons of ORNL's liquid low-level radioactive waste for interim above-ground storage, utilizing commercial vendor technology and manpower, in combination with ORNL waste management staff and facilities (Figs. 10 and 11);

- the transfer of air stripping and groundwater treatment technology experience from The Department of Defense site cleanups to DOE applications through the broad Hazardous Waste Remedial Action Program located in Oak Ridge;
- the import of the tumulus waste disposal technology from the DOE International Technology Exchange agreement with France, and the export of the results of the Oak Ridge demonstration to the state low-level waste disposal compacts;
- the development of an Oak Ridge association for over 36 local commercial firms participating in the DOE Model concept of private sector cooperative involvement in addressing waste management problems; and
- the involvement of regional colleges and universities (including Vanderbilt University, University of Tennessee, Roane State Community College) through direct participation in R&D activities as well as through development of specific waste management degree programs for training the next generation of problem solvers.

ON THE HORIZON

Considering the billions of tax dollars that may be requested of Congress for funding of waste management and remediation projects over the next 10 to 20 years, it would seem prudent to plan to invest some portion of that resource into money-saving R&D programs. Through judicious selection of R&D support at sites with broad capabilities, working problems with wide applicability, and in an environment of government/private cooperation, I feel that we stand the best chance of getting a many-fold return on the invested dollar.

What are the areas most deserving of special attention for future R&D? Even from my fairly narrow view of the world of waste management, I see numerous areas where development dollars in both basic and applied research areas would be of benefit. A brief overview of a few of these follow.

Biotechnologies: The successful deployment of biological treatment, both in-situ and in-process-plant applications, could be the breakthrough that is needed to make large-scale remedial actions cost-effective and environmentally sound. Development of waste-specific organisms for destruction of mixed organics, PCB, and heavy-metal contaminants will be essential to effective cleanup programs.

Waste Minimization: While development work is already under way in this area, more innovative ideas are needed to keep the country from burying itself in its waste. Material substitutions, waste segregation technologies, and waste treatment methodologies that effectively reduced waste generation or minimize waste volume or toxicity are desperately needed to be put into application as soon as possible. Along these lines, an area of local focus in Oak Ridge with nationwide collaboration and international ties is the use of microwave technology for liquid waste processing and volume reduction.

Dilute Solutions Treatment Technologies: Many of the waste management challenges that face operating plants, as well as remedial action planners, center around development of cost-effective treatment technologies for large-volume, low-contaminant concentration waste streams. Whether those streams consist of process cooling waters or contaminated ground or surface waters, there is a great need for focused chemical separations research to reduce the large capital and operating budgets required to continuously treat these waste streams.

Robotics/Artificial Intelligence: Considering the large number of highly contaminated nuclear facilities requiring decommissioning in the next few decades and the need to minimize personnel exposures during those activities, the development and rapid, cost-effective deployment of robotic and artificial intelligent systems appears essential. This highly specialized and technically complex endeavor will need the combined minds of the government and private sector.

Environmental Characterization: Enormous sums of money are being put into groundwater well installations and routine radiochemical sample collection and analyses for surface and subsurface media. This time-consuming and expensive methodology of site characterization and environmental impact analyses is often too slow and may not relate the true impacts to the environment. Smart monitors giving real-time, reliable results for contaminant and geophysical characterizations desperately need to be developed and brought into the field. Similarly, biological monitoring programs, like those pioneered by ORNL staff for the DOE-ORO facilities National Pollutant Discharge Elimination System (NPDES) monitoring requirements, can be successfully used to reduce other routine and more costly sampling and analysis programs.

IN CLOSING

In closing, I want to again express my appreciation for the opportunity to present my views to the Subcommittee on the successes and future needs for waste management R&D.

Thank you, Mr. Chairman. I would be pleased to answer questions.

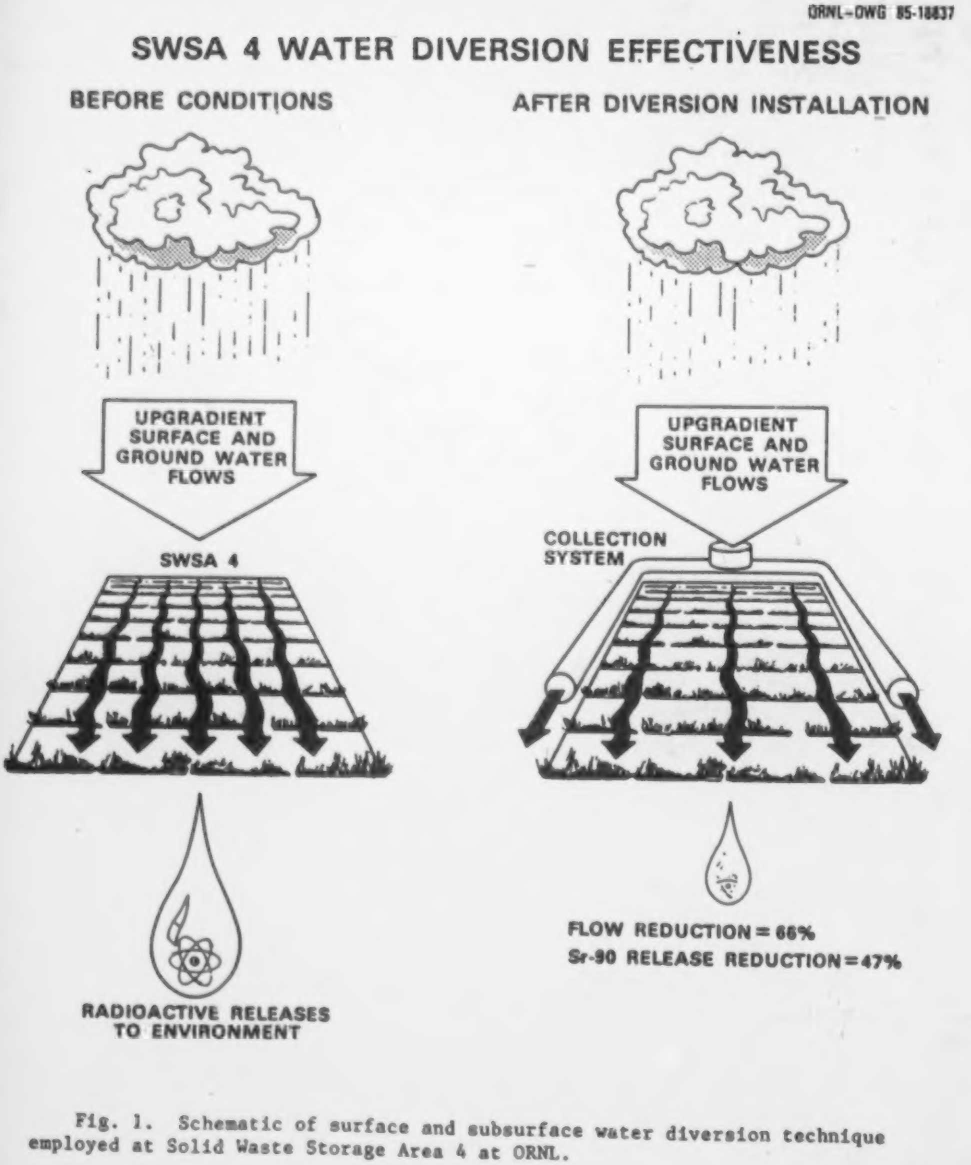
ORNL-DWG 85-18837
SWSA 4 WATER DIVERSION EFFECTIVENESS
BEFORE CONDITIONS
AFTER DIVERSION INSTALLATION
UPGRADIENT SURFACE AND GROUND WATER FLOWS
SWSA 4
RADIOACTIVE RELEASES TO ENVIRONMENT
UPGRADIENT SURFACE AND GROUND WATER FLOWS
COLLECTION SYSTEM
FLOW REDUCTION = 66%
Sr-90 RELEASE REDUCTION = 47%

Fig. 1. Schematic of surface and subsurface water diversion technique employed at Solid Waste Storage Area 4 at ORNL.

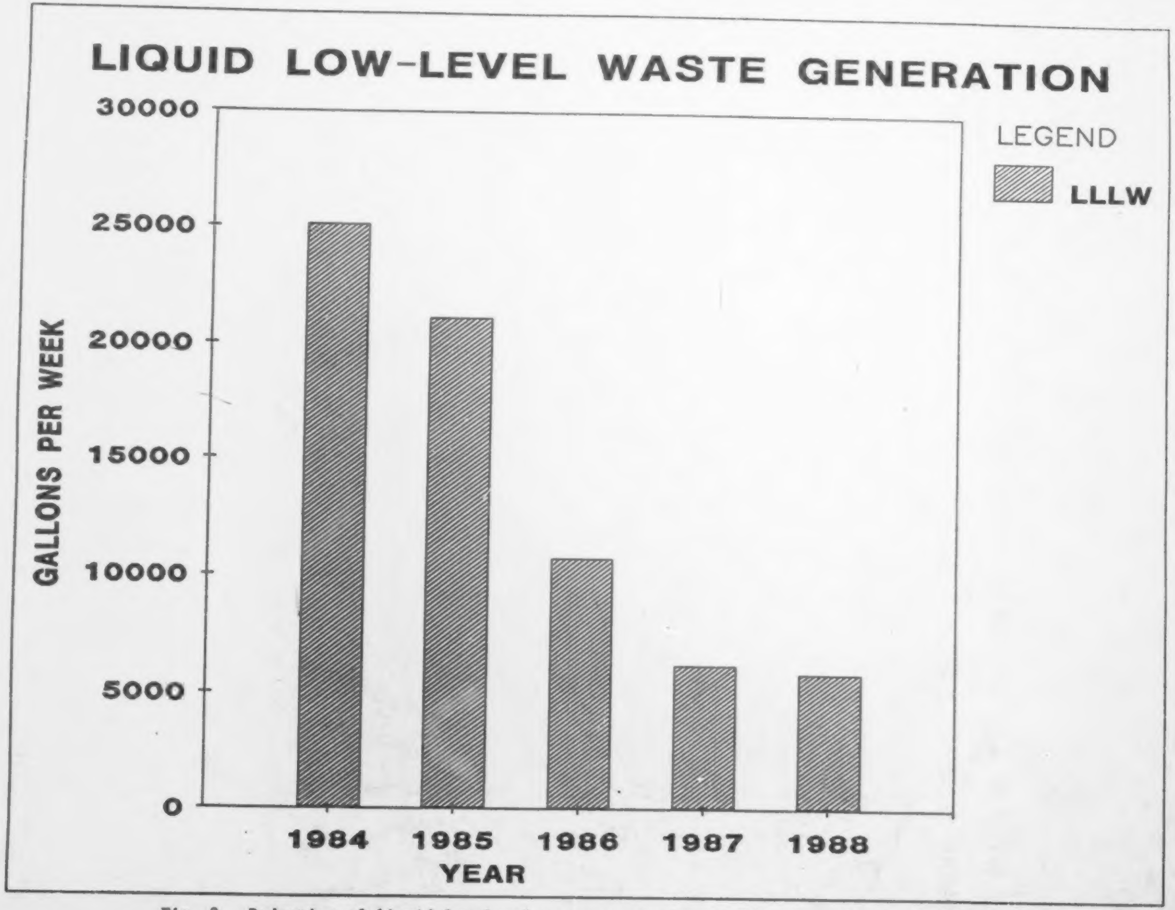

Fig. 2. Reduction of liquid low-level waste generation at ORNL through use of effective waste minimization technologies.

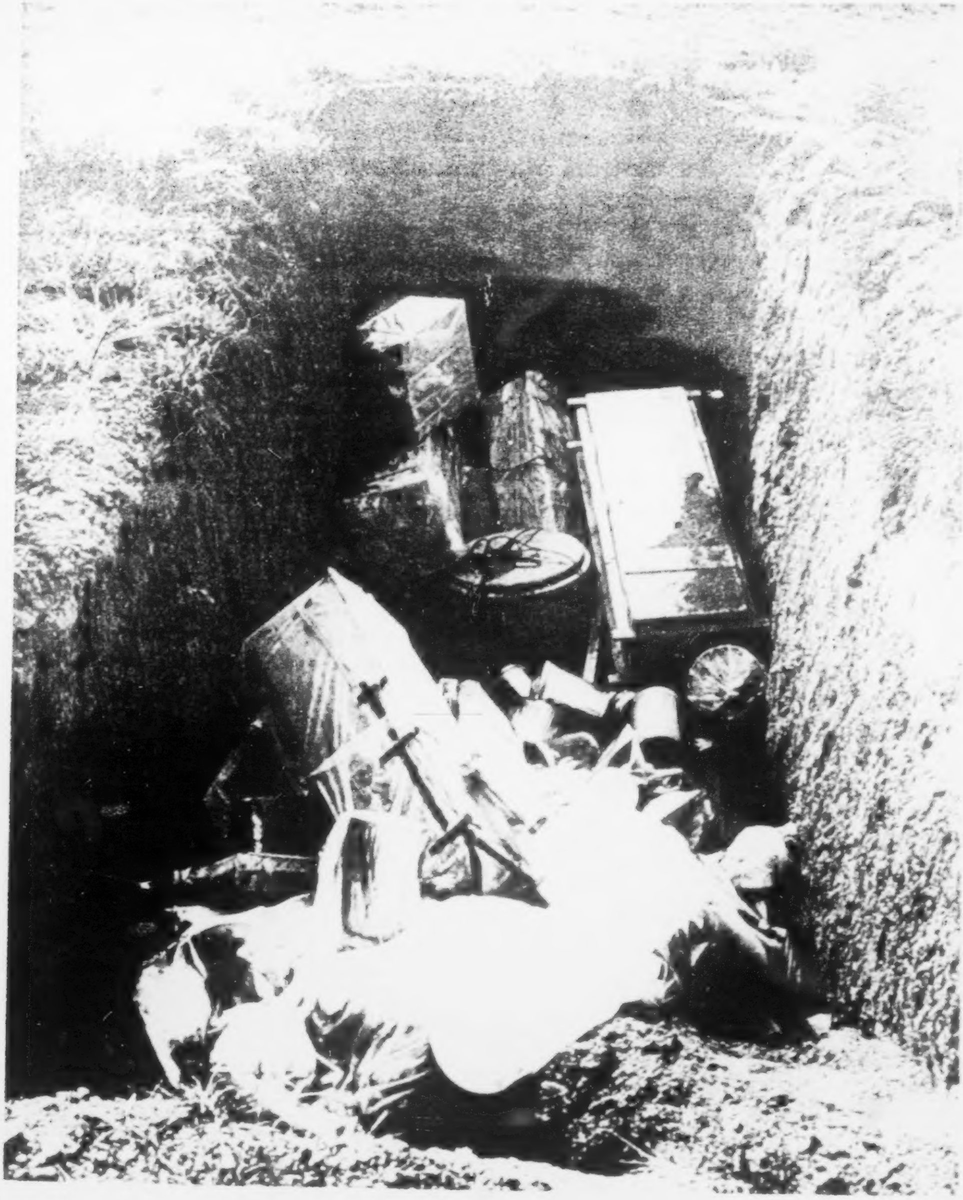

Fig. 3. Old practice of trench disposal - solid low-level radioactive waste.

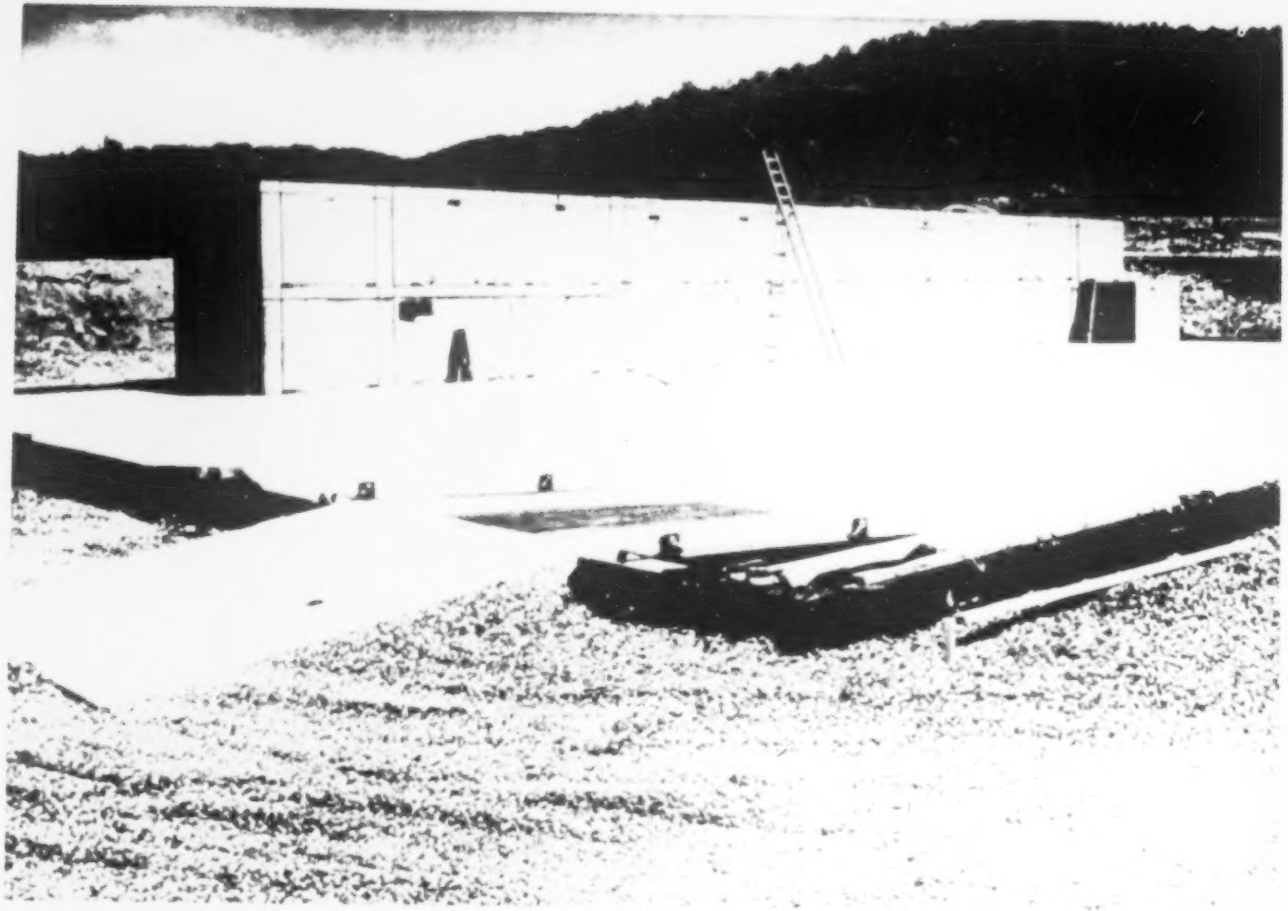

Fig. 4. Tumulus Disposal Demonstration for solid low-level waste. Above-ground disposal using concrete containment for waste and doubly contained leachate collection system.

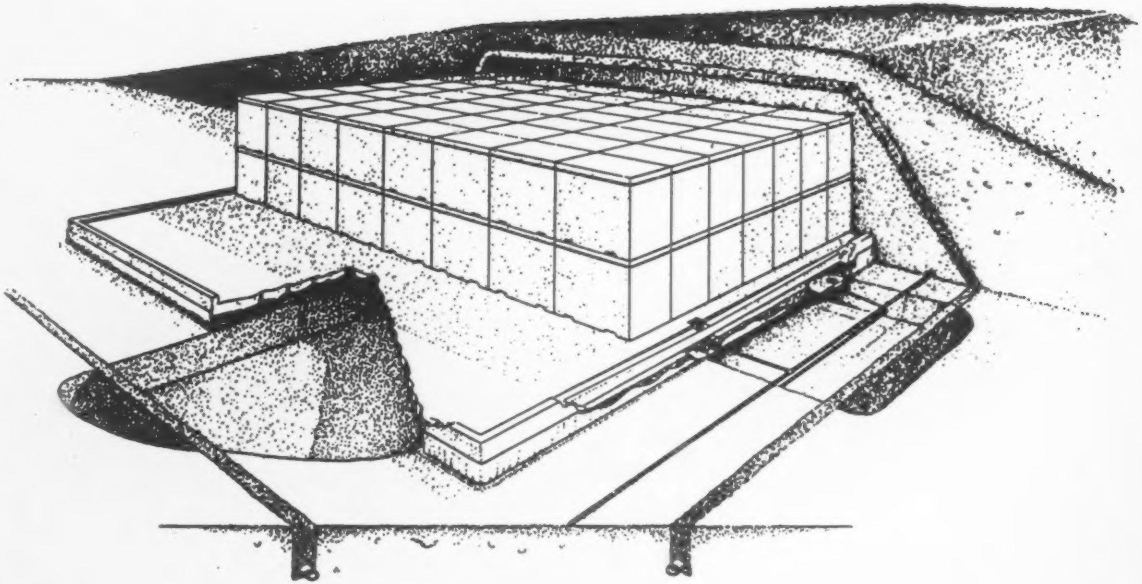

Fig. 5. Artist conception of the Tumulus Demonstration Unit at time of closure.

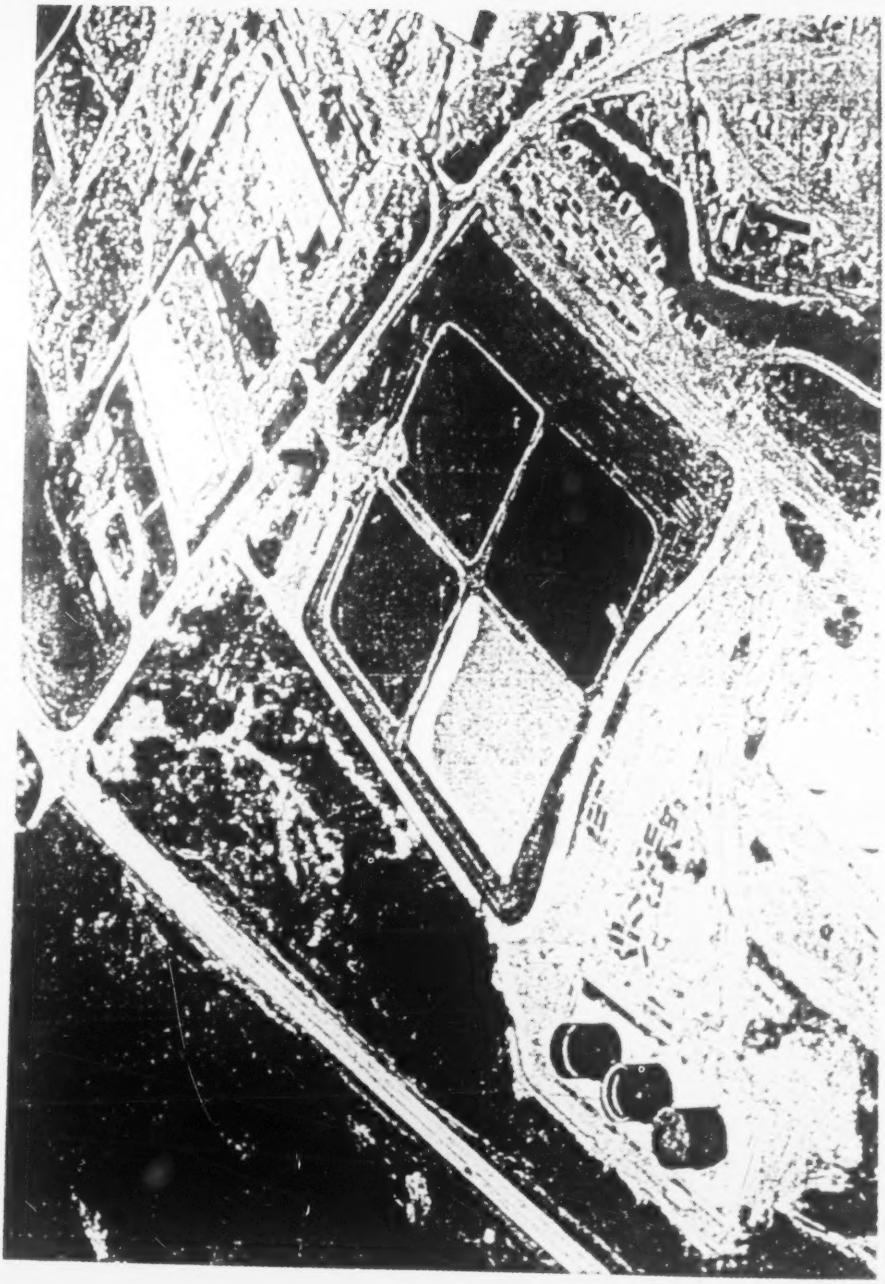

Fig. 6. S-3 ponds in 1983 during biodenitrification.

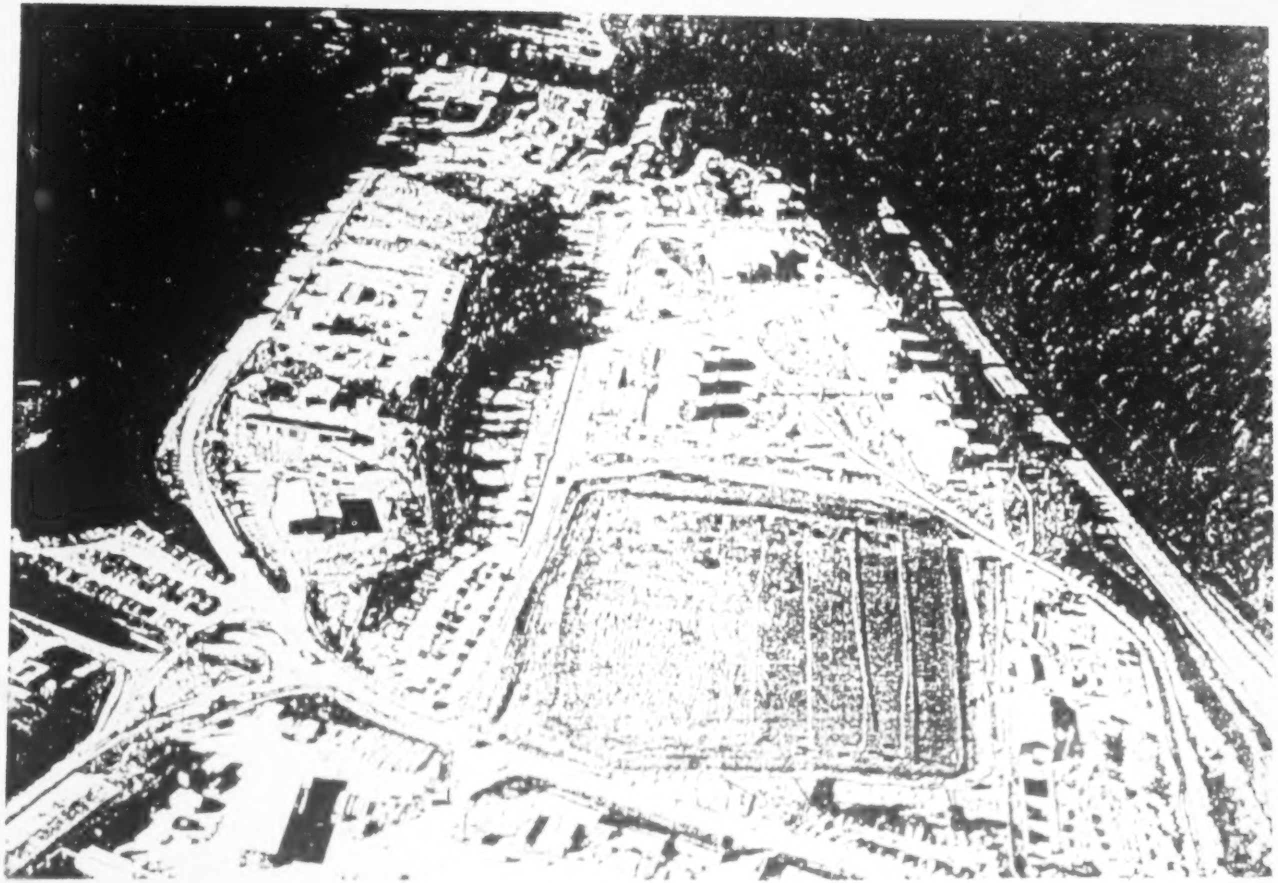

Fig. 7. S-3 ponds after sludge stabilization, installation of 2 feet of clay, liner, and EPA-approved multilayer cap. S-3 ponds were replaced with storage tanks. Three tank farms have been completed. The fourth tank farm to be completed in April 1989.

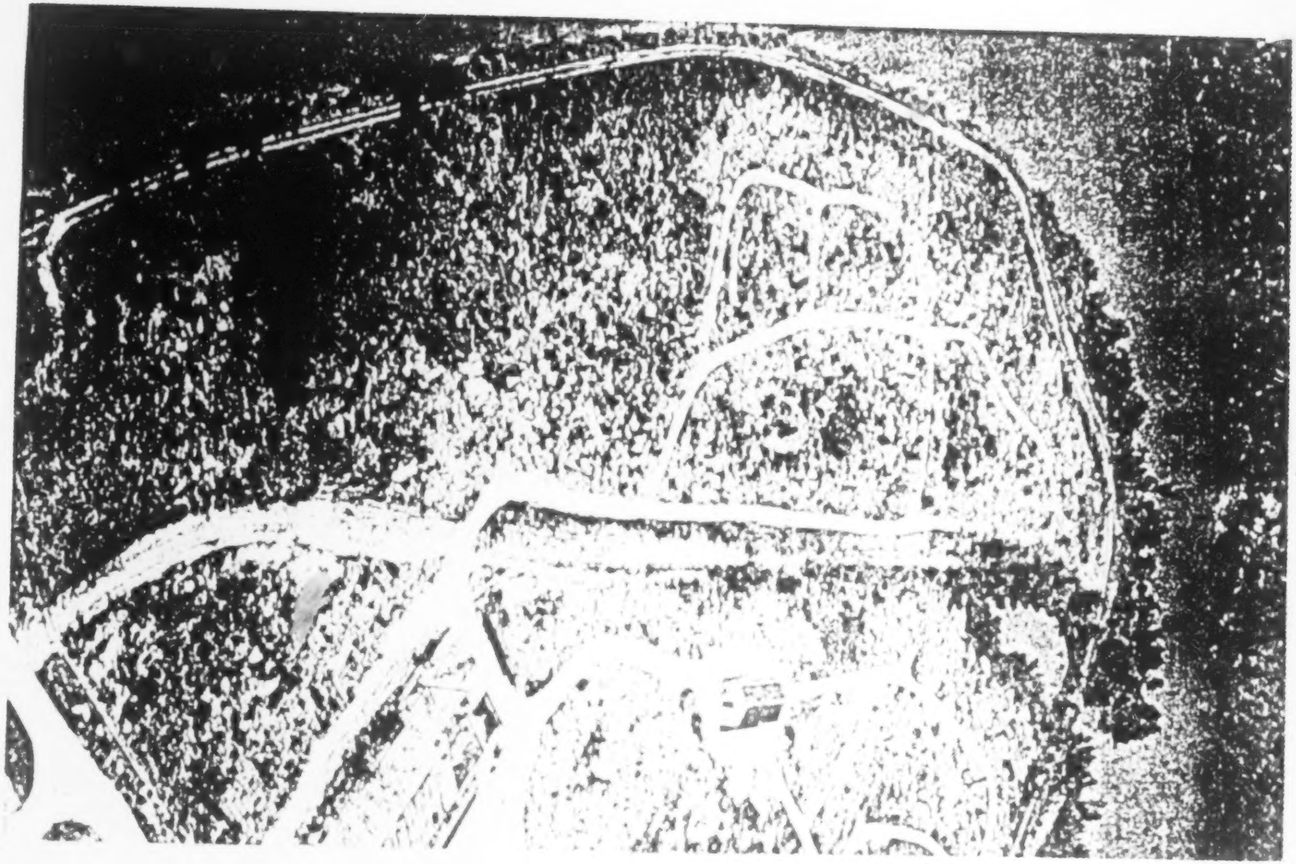

Fig. 8. 30,000 tons of uranium-contaminated metal at ORGDP. Cleanup began in 1983.

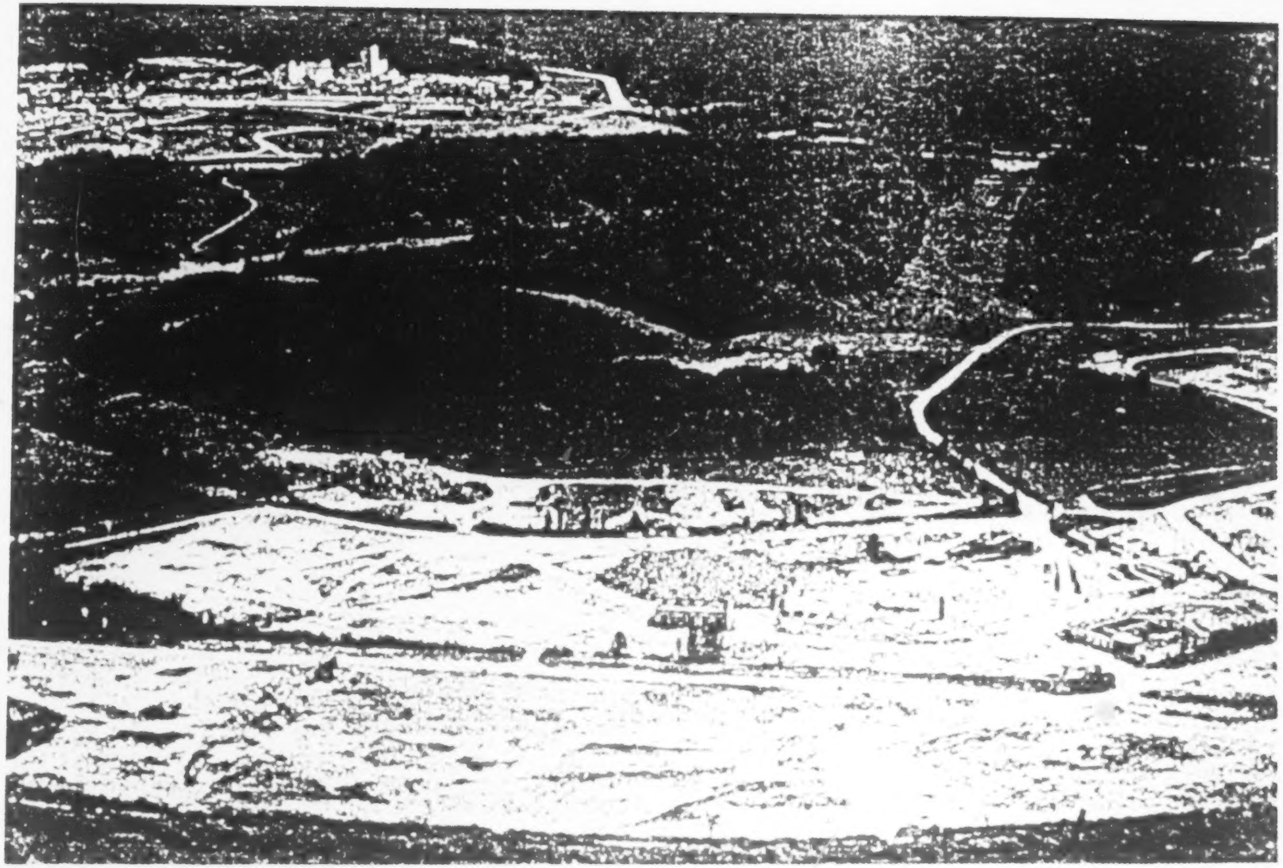

Fig. 9. 30,000 tons of uranium-contaminated metal removed from flood plain at ORGDP in 1986 and sorted by metal types. Two-phase program under way to decontaminate and recycle metal. Sale solicitation released - bids due March 1989.

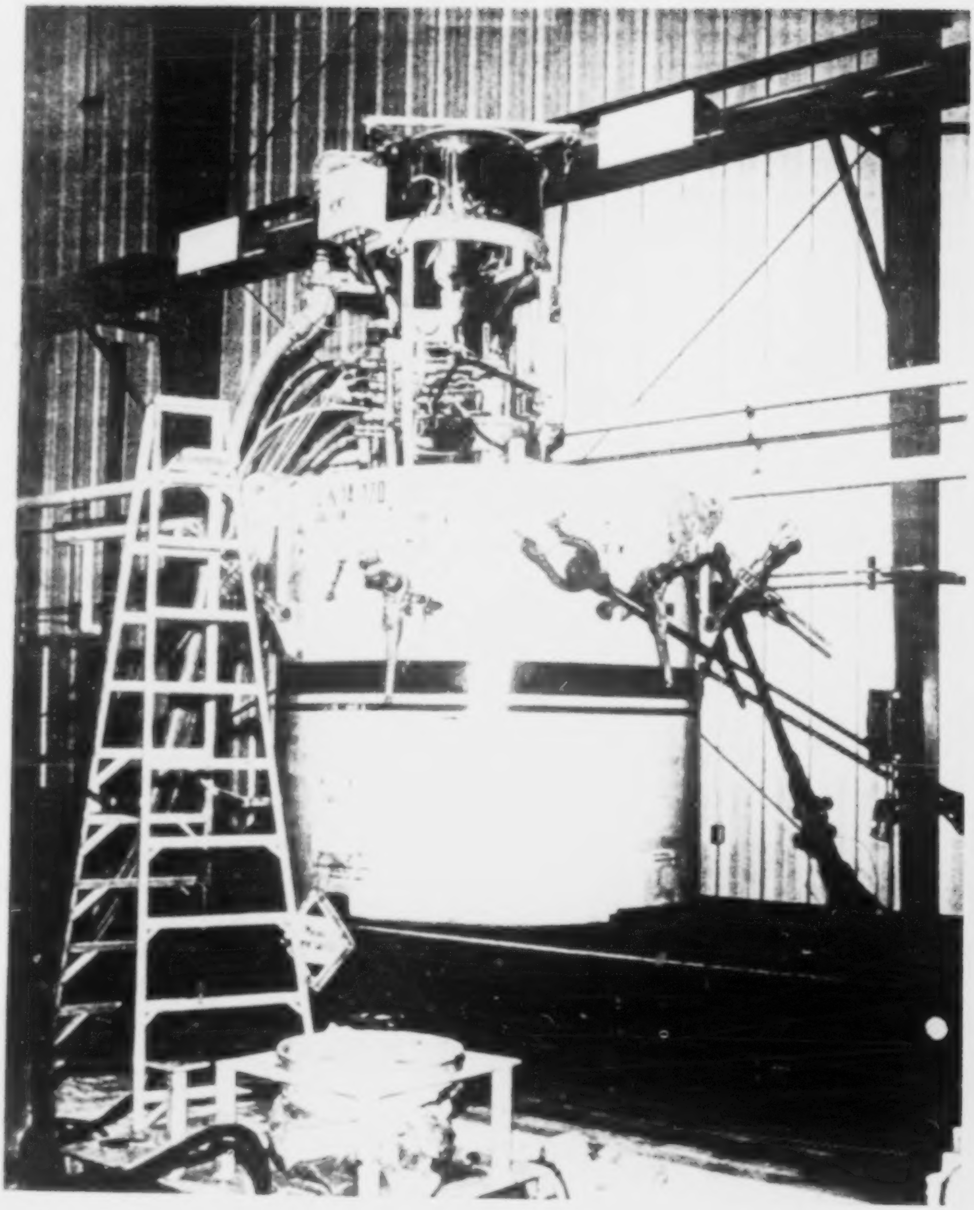

Fig. 10. Liquid low-level waste solidification unit for cement-based radwaste stabilization (unit owned and operated by LN Technologies, Columbia, South Carolina).

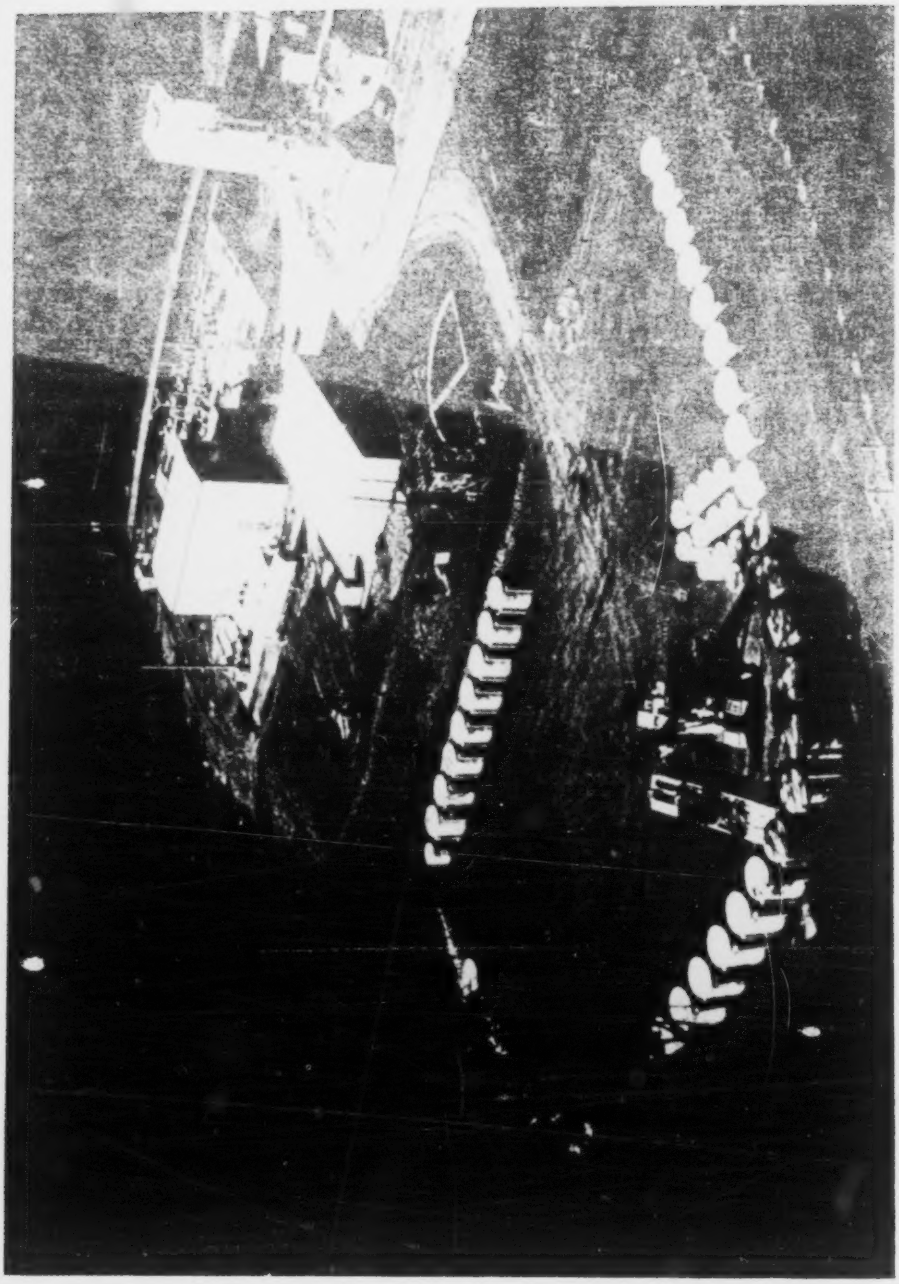

Fig. 11. Interim storage casks containing solidified liquid low-level waste from ORNL waste stabilization campaign.

Mr. SCHEUER. Very good. Thank you very much.

At an earlier hearing on the biological environmental research programs, there was great excitement expressed over the possibilities of using bio-remediation to treat toxic wastes in situ. What work are your labs doing in this area? How close are we to setting up a demonstration project for this particular technological approach? And has the funding that you have received, each of you for your labs, enabled your labs to maximize its research in this area? Or has funding posed a constraint on these research programs?

Dr. WILEY. Well, Mr. Chairman, I think that I'll try and answer those in the order in which you gave them. The first is that there is never enough money to do everything. However, we have been supported by the Department of Energy to look at the presence of microorganisms in deep geologic—

Mr. SCHEUER. In what?

Dr. WILEY. In very deep geologic formations of aquifers. And we have found microorganisms, native microorganisms in these environments. We are in the process now of developing the research data to—and that means what kind of nutrients do you have to add to this environment in order for them to pick up and utilize, to absorb the metals or that sort of thing—to go in with a demonstration of this technology.

We are also looking at the injection process. However, the injection process is not a major effort that has been supported at the Pacific Northwest Laboratory. However, I do know that many of the others are involved in the injection of microorganisms.

Mr. SCHEUER. Dr. Wiley, what kind of time frame are you talking about before we can use these technologies in the field?

Dr. WILEY. I don't know when we can use them in the field, but I think that the demonstration process is headed towards about a two-year demonstration program. So, in two years we hope to be at the stage where we can go through a demonstration program.

Mr. SCHEUER. How long is the demonstration going to take then before it is available in the field?

Dr. WILEY. I will have to get you that information.

Mr. SCHEUER. Very rough.

Dr. WILEY. I suspect that that's probably a two-year problem itself.

Mr. SCHEUER. So in four or five years we might have something on line?

Dr. WILEY. That's correct. Yes.

Mr. SCHEUER. Any of the rest of you?

Dr. WHETTEN. Yes, sir. We're involved in using bacteria to try to degrade waste sites which are contaminated with high explosives. These are actually some laboratory waste sites that are left over from the World War II era and pose, could pose a significant hazard. We think that the bacterial approach is a—appears to be a viable one. We're currently involved in the engineering studies of it, which could perhaps take three to five years before you really have a pilot demonstration project ready to go.

Your questioning about the funding is an interesting one in that this is one which has no~~t been f~~unded directly by the Department. It is funded using our internal research funds from the laboratory.

We think in view of the promise of this technology that it is one that the Department could put additional funding in very usefully in terms of our laboratory.

Mr. SCHEUER. Is that something you're recommending to the Secretary?

Dr. WHETTEN. It is certainly something that we would recommend. We would recommend that the environmental funding for the whole Office of Health and Environmental Research be increased and that the activities in that office be more closely coordinated with the defense waste management, the more applied activities that we're discussing today.

Mr. SCHEUER. Very good.

Dr. SCHOCK. Mr. Chairman, I might just add that in 1984 in a long range planning exercise at our laboratory we recognized that this was one of the up and coming technologies that was likely to have applications in many of the things we do, and so we started, again as John said, with our own internal, you know, institutional research and development funds a concerted effort in biotechnology. Particularly—that builds, rather, on an ongoing effort in the human genome project or the predecessors, really, of the human genome, the cancer risk work that I talked about before. We also had an ongoing effort at the time in monoclonal antibodies which, if you are familiar with those, have a great deal of promise for being able to identify very low levels of toxic materials.

But we are continuing, I mentioned a couple of areas in my testimony; particularly, also like Los Alamos, the cleanup of a GEN using this microbe that converts, in nature, converts methane to methanol and higher hydrocarbons. Turns out that we have discovered that that same animal also converts these toxic compounds into innocuous compounds.

I should say we—in answer to your other two questions, I don't know when we will be done. The answer really couples in with, it's the classic conundrum of, if we had more money we could do it sooner, but we'll eventually get it done with the money we have.

Dr. MYRICK. The only thing I would add is the specific application that's happened at Oak Ridge. We've taken the biodenitrification technique from the lab scale and applied it on full scale. It is part of the testimony I submitted. We have pictures of the S-3 ponds at the Y-12 plant that were closed out using biodenitrification, where we processed several million gallons of liquids in those ponds, destroyed the nitrates with the bio-remediation techniques. We then applied those techniques in a technology export fashion to both Portsmouth and the Fernald plants. So we've taken it from the lab scale and have put it on full scale in closure actions in Oak Ridge.

Mr. SCHEUER. Yes. Well, in connection with you, with your wanting it and if we had more money we could do it quicker, what amount of money would you need to implement your plans fully in 1990 for all of your respective labs, and how does this compare with the monies that you're getting from the funding levels that are in the President's budget?

Dr. WILEY. Well, in our case, Mr. Chairman, we proposed originally a $12 million budget for this $6 million effort that I described to you, and my expectation is we'll get the six. And, so therefore the answer to your question is that we could usefully put another $6 million to work, based upon our original proposal.

Mr. SCHEUER. One would have to calculate on a cost-benefit basis whether it would pay our Government to invest—not spend—

Dr. WILEY. That's correct.

Mr. SCHEUER. Investment in that segment in order to have a technology that has vast applications for which we're eagerly waiting to put in place. I mean, if we had a technology that really could work up at Prince Albert Sound, and they could have caught that stuff early on, and if we didn't develop it because it would have cost another few millions dollars to save several years in the process, a stranger coming from Mars would have to say we've taken leave of our senses.

Dr. WILEY. I agree with you. We're up at the Sound now. We just received a call yesterday to come up and look at the application of some technology that we have not described here but—

Mr. SCHEUER. Well, come on. Give us a break. Do you have anything that is of potential use up there? Let's end this hearing on an up note.

Dr. WILEY. Well, the up note is that I don't know whether this technology will work up there, but we have for some long period of time looked at microbial degradation of hydrocarbons in the ocean environment. However, it was in warm water climates and I don't know whether—you know, these are not cyclophiles, certainly, and the water is going to be awfully cold up there. So I just don't know whether it will work.

Mr. SCHEUER. Any—excuse me.

Dr. WHETTEN. Bill Wiley's introductory statement about the next decade being the year of the environment has a certain ring to it, which I think is probably—may turn out to be prophetic. I think our view is that that R&D that is invested in environmental technologies is essential for the DOE cleanup but it's certainly likely to have much broader application. The Department of Defense is certainly going to discover it—the focus right now is on the Department of Energy because of discoveries and revelations, and so forth, of last year, but the Department of Defense is certainly going to have some problems. When we get around to decommissioning bases from the DOD, there are certainly going to be environmental concerns there which are going to need treatment, and the U.S. private industry is certainly going to be involved much more in environmental remediation and cleanup activities that has been done in the past.

So our view is that monies spent on remediation technologies will certainly be very well spent, and it's our advice and encouragement and to the Congress that money be appropriated to this end.

Mr. SCHEUER. The Secretary of Energy has said that the national labs will be called upon to develop innovative solutions to the environmental problems confronting our Nation. You've just talked about one of unbelievable magnitude and importance.

What is the most efficient way to mobilize the talent and the potential in each of these labs to accomplish the objective that the Secretary has described? Should we designate one lab, for example, as the focus of the environmental research effort or, given the varieties of strengths at the different labs, is a multi-lab approach more amenable to maximally developing the talent that's latent there and unleashing the talent that could produce the needed technologies?

Dr. **Schock**. Mr. Chairman, I think that's a very pertinent question. As we have all alluded, these problems are very complex, and the point I want to make is, and I'm sure you're aware of it, is that the solutions call for different types of answers and lie not only in technological—progress, rather, in technological areas, but also in some institutional and managerial innovation so that we can apply these diverse technologies and also develop new ones. We, basically, need new ways of being organized about this in thinking, and I think we at the national labs have a duty to the Nation to work together. Over the past ten years I am aware that there's been much more cooperation between the national laboratories. I'm very pleased with that and I hope to see it continue. We need to share much more information, and, in this area, we're not going to get it done unless we do that.

Dr. **Wiley**. Well, if I were the Supreme Ruler, I would approach this problem much as we did in the Manhattan Project, which means that you would take advantage of the capabilities of the individual laboratories to impact various areas that have to be impacted in this total process, and approach it from that point of view.

Mr. **Scheuer**. But you had very central direction, did you not, in the Manhattan Project?

Dr. **Wiley**. That's correct.

Mr. **Scheuer**. They directed, I suppose, the work of several labs but with an iron fist in terms of controlling organization and discipline.

Dr. **Wiley**. I am—you know, I'm—it's hard to believe that they could have had that kind of control over the scientific innovation process.

Mr. **Scheuer**. Well, you ask General Groves, if you can get in touch with him.

Dr. **Wiley**. What I meant by that was—

Mr. **Scheuer**. I think he'd tell you that he did.

Dr. **Wiley**. —you have the centralized control, however, but you don't do it to the extent that you're infringing upon the creative process of the scientific community.

Mr. **Scheuer**. Yes. I'm going to recognize Congressman Sid Morrison and then I would ask Congressman Dave Skaggs to come and take the chair, and when Congressman Morrison is finished, then you ask your questions and terminate the hearing. Okay?

Mr. **Morrison**. Thank you, Mr. Chairman. I have a plane leaving in a few minutes, so I appreciate this chance. I'll keep my questioning really very short. I have—my other subcommittee, Energy Research and Development get a chance to interface with these same laboratories and so we're familiar with much of their work, and, in fact, invite everyone to participate in sort of a subcommittee trip to visit with a number of them coming up in June.

Bill Wiley, I'm familiar, of course, with the work of Battelle, but you're doing quite a bit of work for others in the environmental research area, and that's I think one of the strengths of what Battelle brings to the national laboratory field. Who are some of those clients, and can you share any information along these lines with us?

Dr. WILEY. Congressman Morrison, we're working with at least 10 distinct industries right now, and EPRI—the Electric Power Research Institute—in the environmental area as well as EPA, NOAA, the Department of Interior, Department of Fisheries, and just about every Federal agency that has a problem in terms of hazardous waste. We, like the Oak Ridge National Laboratory we just heard, have an environmental management operation which is involved in helping DOD clean up its sites. In fact, we have created some of the robotics that we were discussing earlier for DOD to operate in hazardous environments, which would permit the more rapid cleanup of some of these places.

So we're working with almost all of the agencies through our private contract. We have a unique arrangement with the Department of Energy which permits us to pay in advance, but to use DOE facilities and equipment for work for private companies, and that's a very effective technology transfer mode.

Mr. MORRISON. Is it fair to assume that this sort of process really allows you to multiply the effectiveness of research by sharing it?

Dr. WILEY. By sharing the research and by getting industry involved at an early stage where they are paying for the movement of technology from the public sector to the private sector where they can, perhaps, make some money out of it.

Mr. MORRISON. What are your plans for staffing as far as this Environmental Center of Excellence that you describe in your testimony?

Dr. WILEY. The Environmental Center of—Research Center will essentially have about 150 people, Congressman, and I suspect about 60 percent of those will be hired from various places around the country.

Mr. MORRISON. Including from some of the gentlemen there at the table, perhaps?

Dr. WILEY. Well, John Whetten here might want to, since he had worked at the University of Washington he might want to come back and participate in this. Yes, sir.

Mr. MORRISON. I'm pleased with the responsibility and, of course, I'm aware also and appreciate the testimony of others here. I point out—I'm sorry the chairman has left—but that thing that looks like a lump of coal, if you're from the East Coast, is one of those projects that didn't really cost very much as far as Federal dollars are concerned. That was just plain soil and rock, potentially contaminated, before it was turned to glass, and it is an exciting technique if, in fact, your goal is to stabilize materials in place. I don't think ultimately that's our goal, but, in fact, it is one of the techniques that we obviously will have to use. And developed at very low cost, as I recall, Dr. Wiley?

Dr. WILEY. Very low cost. Again, this was developed by the use of internal funds. We thought this might be a feasible, economic idea, so we invested some money in some very basic, fundamental work and carried this work on until we reached the stage of demonstration. At that point the Department decided to put money into it. Very inexpensive development. Seven years in development.

Mr. **Morrison**. I would make just a statement for the record as I head for the airport. That we've seen in yesterday's hearing on tabletop fusion and on some developments I've seen like the in situ vitrification, that I think it would benefit us in our budgeting if we provided as much flexibility as we could for the scientific community. And I think you gentlemen representing our national laboratories, in which we have tremendous pride, would also benefit if you let some of your people go and let them, really, on their own answer some of the problems we face in today's society.

Thank you, Mr. Chairman.

Mr. **Skaggs**. [presiding] Thank you, Sid, and have a good flight home—assuming that is where you're headed.

Mr. **Morrison**. I'll fly over Colorado—

Mr. **Skaggs**. Yes. Be kind as you go over.

I have a few questions I'd like to pose to you all. Secretary Watkins when he took office surprised, I think, many of us by his comments that essentially the orders of magni—or the order of magnitude of cost of cleanup, he believes, has been exaggerated, or perhaps more accurately, he hopes has been exaggerated, and that he intends to see if, by golly, we can't get the weapons complex cleaned up at less than the $80 to $100 billion cost that's discussed most of the time.

I realize this is asking for your speculation because I don't think anybody really has a handle on this now, but to the extent that you want to compare speculations with the Secretary's, what are yours? Do you see from your laboratories the kind of promise for cheaper ways of getting this job done that could inform a lower cost estimate?

Dr. **Whetten**. We don't have any independent assessment of the overall cost, but we looked with some concern and alarm at the costs that were raised simply because they were so very high. But, yes, Congressman, it's our view that new technologies can substantially reduce the cost of the cleanup. For example, one thing that one has to do consistently is monitor and assess what you're doing and use as much predictive capability as you can to figure out where the contamination is going, how much you have, and so forth. And it's these kinds of monitoring and assessment tools that can immediately save a great deal of money.

This midget mass spectrometer that I mentioned, for example, if we—at a total cost of several tens of thousands of dollars, if we can make measurements cheaply in the field in real time, you know, it will save an enormous amount of money, which I'm sure was calculated in some of the cost estimates that have been given for the cleanup. So we think that driving down the cost should be one of the chief reasons for investing in applied environmental R&D.

Mr. **Skaggs**. Any of you other gentlemen?

Dr. **Wiley**. Mr. Chairman, I would say that certainly with existing technology I doubt that you can do this job—that's my own personal view—do this job any cheaper than what has been proposed. However, with new technology, if we can get that technology developed in a manner which is—quickly. We're involved, for example, now in the process of a little information system, which we're calling VISTA. It's vertical integration of science, technology and applications, is what we're talking about, where this thing takes information from the permitting system, from the legal and regulatory requirements and works it into a technological solution. If we are able to put all of that into our technology development such that when you get ready to permit a new technology for cleanup that you don't have seven years in court, then I think we can decrease the cost of this exercise. It's just a matter of working smarter.

For example, we may have the solution to the cancer problem. We may have solved cancer, but we don't know it because the information is so dispersed and so distributed that you cannot analyze the data in a manner which would permit you to say you have the solution. We have to change that way of operating and approach it in a much more intelligent fashion.

Mr. Skaggs. Dr. Schock, you seem to be—

Dr. Schock. I might just add, Mr. Chairman, that our own contribution to that number, whether it's $30 or $100 billion—It was about $1.2 billion. That's for the Livermore site cleanup. When we looked at that, we found out that there was more in there. When we looked at our number in retrospect and looked at the way it was asked for, there was more in there. That number, in fact, includes all of our waste minimization and waste monitoring activities over the time period of that study, so the cleanup itself is only about $200 million. I shouldn't say only, but it's about $200 million of that $1.2 billion figure.

If other things—if there are other examples at other laboratories, in fact, the number would be lower and the Admiral might, in fact, be on very good ground.

I would second what Dr. Wiley said about smart—he used the term smart. I think that's, if we look back at what we've been doing in the past, we have not been very smart in many cases before we've started our cleanup. And by smart, I mean finding out what's there, where it's likely to go, what its risk is to human beings, to the environment and to human beings.

I would also agree with Dr. Wiley that we don't have all the technologies that are going to be needed to deal with this problem and we're going to have to come up with some new ones.

Dr. Myrick. And I'll only add one additional comment. I think one of the keys will be the in situ versus the dig-up. If the numbers have been based on a dig-up campaign, and you can in fact go with an in situ technology, those numbers can go way down. If, however, the regulatory environment at those sites demand that the stuff be removed, then we're in big trouble.

Mr. Skaggs. Following up on that, the sites and the Rocky Flats plant where I come from, at least the most serious ones, involve threats of some migration of contaminated groundwater or migration of contaminants in the groundwater and, so the trade-off that is apparent between taking the time to do the R&D to get the better widget versus a dispersal and therefore bigger or more widespread cleanup problem years hence is facing us, and I'm sure that's typical of many of these other sites. Particularly troublesome when the public has been brought to a high state of awareness and sensitivity and wants to see something happening to get this thing under control.

Can you offer at least any construct for a public policymaker on, you know, how to assess that trade-off problem?

Dr. Wiley. Well, I would—Mr. Chairman, I would say that I was very interested in the discussion of that earlier today where I think the French drain concept was introduced as an interim methodology. I think that there are a number of places where we're going to have to introduce these interim processes that prevent continuous degradation of groundwater, but I don't think that we can afford to use those interim solutions as the final solution, the final cleanup of the environment. I think we have to take what interim steps we need to take and at the time continue to make these investments in research that will permit us to put it to bed forever.

Dr. Whetten. I think one question, Congressman, is really the extent to which you as a public policymaker are willing to allow Rocky Flats, say, to be used as a demonstration for promising but as yet unproved technologies. I think this is a substantial problem in the sense that if we follow the present rules and regulations in order to get a technology on the EPA approved list a great deal of time in proving is required. If you want to shortcut that, I think there are some potential technologies which could substantially improve the situation at a place like Rocky Flats, particularly regarding the organic contamination, but the only way we're going to know is if we try. And to do that there I think has to be some substantial bending of the permitting rules to allow some of these promising technologies to be applied to that area.

Mr. Skaggs. Would you be willing to, yourself or through your staff, perhaps, suggest specifically how we might frame exceptions to the normal EPA process and in a way that would be protective of both experimental and public concerns?

Dr. Whetten. We would be glad to respond to you on that question.

Mr. Skaggs. I'd appreciate seeing what that might look like and how we could do a better a job there.

Dr. Whetten. Okay.

Mr. Skaggs. Dr. Schock?

Dr. Schock. If I might just make two quick points. I think it is very important to do the assessments up front. That the dangers to society are that we—by not doing it right in the first place, we could in fact make the problem worse, and I'm sure you're aware of that.

Second point is that there are in many cases, for example, with plutonium we're on—a lot of work has gone into that and we have a very good idea of what the risk is to mankind. On the other hand, the volatile organic compounds, I don't think we're on anywhere near as safe ground in terms of what the hazard really is and where it comes from, and so that's why in that case I would argue that we do need to sit back and take a careful look at it.

Mr. Skaggs. And, Dr. Schock, in your statement you spent some time talking about the promise that incineration holds. Particularly to you, but anyone else that might want to comment, I'm interested in the hazards or promise, depending on your point of view, of the use of incineration to at least reduce the volume of plutonium-contaminated hazardous wastes. That's one technology that's being examined at Rocky Flats and I'm interested in what the scientific community's view is on that possible methodology for plutonium, in particular.

Dr. SCHOCK. Well, I can't really comment on the plutonium aspects except to say that the volatile organic components, of course, can be combusted, to basically, carbon dioxide and water. At Livermore we're looking at a small subset of that problem for our own incinerator, and are trying very hard to come up with some of these innovative techniques which get the plutonium and other radioactive components out of the mixed waste before it gets incinerated because we just simply do not want to put that stuff up the stack.

Mr. SKAGGS. That's the troubling thing about the proposal at the Rocky Flats plant, which is a mixed waste problem. Are you familiar with their efforts here at all?

Dr. SCHOCK. Just vaguely.

Mr. SKAGGS. I'd appreciate it if, not for the record, but if you could provide my office with the name of whoever at Lawrence Livermore is working in that area. I'd like to be able to get in touch.

Dr. SCHOCK. Be glad to do that.

Mr. SKAGGS. Thank you. One final question, I guess. I've heard various comments from you all about getting into private hands the technologies that you are developing and are in the process of proving out. Is there anything more that we need to be doing in Congress to assist, either legally or in other ways, in that effort to get what you're doing where it needs to go, as far as applied use?

Dr. WILEY. My opinion at the present time, Mr. Chairman, is that we have all the legislation, all of the regulations and the Stephenson-Wydler—all of the laws and rules that we need to make this happen. I think it's just a matter of getting the attention of industry at an earlier stage in technological development. I think that's the critical issue.

Mr. SKAGGS. We had hearings on this in my area a couple of years ago in which it was basically stated that this is a contact sport and the real problem is getting the right people to talk to each other and you can't pass laws to make that happen.

Dr. WILEY. Right. That's right.

Mr. SKAGGS. Any other observations?

Dr. WHETTEN. The whole question of technology transfer is an important one for the Nation and I think attention is being focused on that in the Department. We've seen a great deal of interest in changing some of the more conservative policies over the past couple of years. We've made some inroads in some special areas—high temperature superconductivity pilot centers, which exist at Los Alamos, Oak Ridge, and Argonne, where the Department has gone even further in bending some of its rules in order to encourage technology transfer. We would hope for a wider application of some of these more liberalized rules and policies into other areas, and hope to be working with the Department toward that end.

Mr. **Skaggs.** Well, I appreciate your time in staying with us this afternoon through an earlier panel and your contribution to the work of the subcommittee.

And we will stand adjourned. Thank you very much.

[Whereupon, at 3:43 p.m., the subcommittee was adjourned, to reconvene subject to the call of the chair.]

APPENDIX I

STATEMENT OF DR. JOHN BRADEMAS

PRESIDENT, NEW YORK UNIVERSITY

SUBMITTED TO THE

SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURE RESEARCH, AND ENVIRONMENT

OF THE

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

U.S. HOUSE OF REPRESENTATIVES
WASHINGTON, D.C.

APRIL 21, 1989

INTRODUCTION

Mr. Chairman, as President of New York University, I am pleased to submit testimony to the Subcommittee on Natural Resources, Agriculture Research, and Environment on the Department of Energy Authorization Bill on behalf of New York University's request for Federal support to assist in constructing and equipping the New York University Center for Neural Science.

NEURAL SCIENCE RESEARCH AND THE U.S. DEPARTMENT OF ENERGY

The Department of Energy currently supports several important areas of research related to neural science. Through its Basic Energy Sciences budget, the Department supports mathematical science, computer science, computational modeling, and other work related to examining how information is processed -- all areas of inquiry to which the functioning of the brain and neural systems are directly relevant.

Moreover, under DOE's Biological and Environmental Research budget, funding is made available for the study of the effects of environmental agents on brain development and activity.

A third area of the Department's budget -- Environment, Safety and Health -- funds research on brain imaging and the psychological and neural factors that affect brain performance.

The Department of Energy, therefore, plays a key -- and in many instances a unique -- role in neural science.

NEW YORK UNIVERSITY AND NEURAL SCIENCE

In recent years, dramatic advances in neuroscience have resulted from collaborations among physiologists, anatomists, chemists, behavioral scientists, and others. NYU scientists working in all these fields have increasingly focused their efforts on the nervous system, particularly in exploring how the human nervous system processes sensory input, organizes behavior, and controls motor output.

New York University's well-established strengths in mathematics and computer science -- the University's Courant Institute is one of the world's premier mathematics research centers -- as well as in experimental psychology provide the cornerstones of the University's focus on functionally identified systems within the brain. The University's research capabilities and its emphasis on systems neuroscience distinguish its program from more molecular and cellular approaches to neural science research, which tend to concentrate on the structure and function of the components of the brain. (This latter type of research is common to medical school neuroscience programs, and much emphasized by the research and funding programs of the National Institutes of Health.)

NYU researchers are developing mathematical models and parallel computational methods to assess brain activity and information processing. Basic research developments in these areas will continue to yield concepts useful in computer neural networks, computer vision and robotics.

The University also has a strong interest in exploring how environmental and biological growth factors control the development of the brain and related organs. Immunological studies of the nervous system and pharmacological studies of the action of biochemical agents on neural tissues, as well as research that utilizes magnetic and related neuro-diagnostic techniques for brain imaging can contribute greatly to our understanding of the health effects and possible hazards of energy production.

Studies are also being conducted by NYU researchers on the cognitive and neural bases of skilled performance under stress, with specific relevance to psychological and neural factors.

THE NEW YORK UNIVERSITY CENTER FOR NEURAL SCIENCE — REQUEST FOR SUPPORT

On behalf of New York University, I should like to request your support in securing the assistance of the Federal Government, in partnership with the University and the State of New York, for the New York University Center for Neural Science.

The New York University Center for Neural Science was established in September 1987 with the aid of a $5 million grant from the State of New York. NYU has already committed close to $4 million of our own resources to the project and plans to spend another $4 million over the next five years on faculty salaries, curriculum development, support for postdoctoral scientists and graduate students, and other operating costs. The planning and design of the Center's new facilities are well underway and we are slated to begin construction by midsummer, 1989.

New York University is seeking Federal support now to complete development of the Center's facilities. Specifically we are seeking a one-time Federal contribution of $10 million -- half the estimated $20 million total cost of the project -- for the construction of shared facilities and laboratories, the purchase of specialized equipment and additional renovation expenses.

When fully completed, the Center for Neural Science will occupy a sizeable portion of the Meyer Hall complex, an existing structure comprised of several buildings, which is located at the NYU Washington Square campus in New York City. The Center will enable the University to bring together individual scientists and research teams in a distinctive first-class facility, where researchers will be able to share ideas, findings, techniques and equipment.

The Center will also educate exceptionally capable students and generate future scientists who will make important contributions to the neurosciences and to our national goals. A new multi-disciplinary Ph.D. program has been designed by the University and is now under review by the State of New York. NYU also plans to offer an undergraduate major in neuroscience.

Here let me offer several clarifications of our request.

First, the Federal share of the costs of developing the Center will constitute no more than 50 percent of the total expense. NYU is prepared to match the Department of Energy's contribution with the $5 million New York State grant and an additional $5 million committed by the University and private donors.

Second, none of the $10 million that we request to have included in the Deparment of Energy Authorization Bill will be used for operations, maintenance or research activities.

On the research front, NYU has already shown it can attract significant levels of support. For example, faculty presently affiliated with the NYU Center for Neural Science are conducting research projects that have already received $7.4 million in Federal support. An additional $5.1 million is committed to these projects over the next five years. Research proposals totaling more than $10 million are pending before Federal departments and agencies. And as the Center's research activities expand, we expect to receive even more Federal support.

NYU is in the process of making six new faculty appointments in the neural sciences. These new faculty will be recruited on the basis of their ability to complement the skills and talents of the 30 researchers already affiliated with the Center, and most likely will represent such research areas as photoreception, psychophysics, neuroanatomy, computational modeling and neurobiology.

Finally, it is important to underscore that New York University has never before sought direct assistance for facilities development from Congress and does so only after fully exploring all other options. The University now, however, faces severe constraints with regard to financing new facilites. NYU has a limited per-student endowment and is precluded from seeking additional tax-exempt financing for capital projects by the Tax Reform Act of 1986. And, as you may know, there are still no programs currently funded at the Federal level to address the scientific infrastructure needs of major research universities.

CONCLUSION

Mr. Chairman, advances in the field of neural science have important implications for energy technology and research, and promise significant social and economic benefits to both the State of New York and the nation.

As I have indicated, New York University has made a substantial investment of its own scientific, administrative and financial resources in our Center for Neural Science. The University has also garnered bipartisan support from the Governor and State Legislature of New York.

The request I submit to you on behalf of New York University is for a one-time $10 million appropriation to assist with constructing and equipping facilities required to make the Center for Neural Science fully functional.

I should note here that in addition to the basic research advances I have earlier mentioned, the work of the New York University Center for Neural Science will have substantial commercial applications in such fields as pharmaceuticals, prosthetics and communication technologies for the handicapped. As we continue to struggle with the effects of a national drug epidemic, it is worth observing that studies of the interaction between drugs and the brain are essential to understanding, treating and controlling drug addiction.

Universities like the one I lead are vital to our nation's research efforts. Yet the costs of simply maintaining first-rate physical facilities are staggering and continue to mount.

As you may be aware, recent estimates suggest that $60 billion would be required to meet the current capital renewal and replacement needs of U.S. colleges and universities. Obviously, the Federal government cannot be expected to fund this entire expense. Colleges and universities must show initiative in generating and directing their own resources toward this purpose.

New York University has shown such initiative by establishing the Center for Neural Science, which will provide a forum, focus, and identity for a unique and productive approach to neural science research. We now respectfully request your help in forming a Federal-State-University partnership to promote scientific discovery and technological progress in this vitally important area.

TESTIMONY OF GERALD U. ULRIKSON, Ph.D.
for the
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT
May 1, 1989

I am Gerald U. Ulrikson, Group Senior Vice President of Science Applications International Corporation (SAIC). I joined SAIC in October 1978 and currently manage the Engineering and Information Management Group based in Oak Ridge, Tennessee.

Science Applications International Corporation is a diversified, high-technology company with approximately 10,000 employees focusing primarily on the areas of national security, energy, environment and health, and high-technology products. We are a national company, dedicated to working on programs of national importance and serving the nation. We support more than 200 offices, strategically positioned throughout the country for close customer support. Through a number of these offices SAIC provides substantial technical and management support to the Department of Energy's (DOE's) headquarters and operations offices. In Oak Ridge alone we have more than 250 employees and are projecting a doubling of staff here over the next five years.

SAIC has a national network of environmental remediation experts who are being called upon more and more to provide technical and management support at DOE facilities. We also hold numerous major contracts with the Environmental Protection Agency, Department of Defense, state government, and private industry for developing, evaluating and/or overseeing the application of a wide variety of waste treatment technologies on a national basis. In Oak Ridge we are working on environmental remediation efforts at several DOE Oak Ridge Operations (DOE/ORO) facilities and are providing support for DOE/ORO's Hazardous Waste Remedial Action Program (HAZWRAP). In short, we are integrally involved in developing and applying environmental remediation technologies for DOE and other government and private concerns on a national basis.

Most of SAIC's current environmental remediation work for DOE originates in Oak Ridge, where DOE/ORO has made early and concerted efforts to address this serious problem. These efforts have tapped a substantial amount of the knowledge and expertise available in private firms such as SAIC, many of whom have located offices in Oak Ridge. In fact, the latest count reveals that 36 waste management firms have offices in Oak Ridge, representing over 2000 local employees.

Your Subcommittee's specific concern for assessing the adequacy of currently available technologies and the need for new and innovative technologies to address environmental problems at DOE facilities is timely and of great national importance. This is especially true when you consider the staggering environmental remediation costs which have been estimated for DOE facilities around the country. Our general feeling is that many of the needed waste treatment technologies do currently exist, but only a few have been appropriately demonstrated on DOE wastes, particularly on the large amounts of hazardous and radioactive mixed wastes which DOE must handle. DOE/ORO began a program several years ago which is designed to make characteristic DOE wastes known and available to private industry. The Waste Management Technology Center was formed to serve as a focal point for prototype programs to allow industry to demonstrate new and innovative waste treatment technology on these DOE wastes. Several demonstrations have already shown the general applicability of existing technologies and have led to identifying refinements which are needed before their full-scale application for cleaning up DOE-specific wastes. We believe this program and approach is sound and highly productive. Expansion of this approach, which has been referred to in the context of the "DOE Model" for capitalizing on private sector technology, should result in accelerated remediation and lower costs to the public.

Much of the technology needed for environmental remediation at DOE facilities is available from private industry in reasonably advanced stages of development (e.g., air stripping of volatile organics and thermal destruction of PCBs). However, we feel that new and innovative waste treatment technologies need to continue to be developed and demonstrated, especially for the large volumes of mixed waste associated with DOE's operations. DOE/ORO's HAZWRAP program has been coordinating such an effort for DOE headquarters over the past several years. This Hazardous Chemical Waste Research and Development Program surveys the specific needs from DOE Defense Program sites around the country and coordinates funding of individual site programs. Continued and expanded research and development on new technologies should be pursued by those DOE national laboratories around the country that can apply specific concepts and experience to the problem. This also should result in lowering DOE waste treatment costs and accelerating the remediation process.

There are several other areas which we believe are critical to addressing DOE's environmental remediation challenges. Most of these center around what must be done to attract private industry involvement (talent, technology, and investment) into the government arena. It should be evident that the government by itself does not have adequate time or funds available to meet the capital facilities requirements of environmental laws and regulations. Private industry must be provided appropriate incentives to locate, construct, and operate waste treatment facilities to aid in the government's own cleanup efforts. In a recent DOE/ORO forum on privatization which attracted senior representatives from most major national waste treatment firms, a number of issues surfaced which are seen as impediments to private industry putting its resources into a government market. These include balancing the high-risk issues (e.g., liability, uncertainty in environmental permitting, waste transportation, waste supply, contracting procedures) against allowing a reasonable return on investment. To date, this has been more reasonably assured by handling private industry's wastes. Innovative government programs and contracting procedures will be needed to encourage the substantive privatization which must occur to help DOE in the future.

We hope the information provided above will be of benefit to the Subcommittee on Natural Resources, Agriculture Research and Environment. We have only briefly raised several of the key issues which we feel merit thorough evaluation as DOE moves ahead with its environmental remediation efforts. We will be happy to elaborate further on the points we have raised or answer any questions your staff or members might have.

ACNP
American
College of
Nuclear
Physicians

1101 Connecticut Avenue, N.W. • Suite 700 • Washington, D.C. 20036
202-429-5120

SNM
The Society
of Nuclear
Medicine

RECOMMENDATIONS OF
THE SOCIETY OF NUCLEAR MEDICINE
AND
AMERICAN COLLEGE OF NUCLEAR PHYSICIANS

CONCERNING THE
DEPARTMENT OF ENERGY'S FISCAL YEAR 1990 BUDGET
FOR THE
NUCLEAR MEDICINE RESEARCH PROGRAM

SUBMITTED TO

NATURAL RESOURCES, AGRICULTURE RESEARCH
AND ENVIRONMENT SUBCOMMITTEE

APRIL 14, 1989

SUMMARY

FY 1990 FUNDING RECOMMENDATION

The Nuclear Medicine research program under DOE's Biological and Environmental Research (BER) program has been severely underfunded over the past decade. Because of flat annual funding increases that have not kept pace with inflation, disruptive earmarks of scarce Nuclear Medicine funds, and internal programmatic reallocations within the BER program, there has been insufficient funding to support the base Nuclear Medicine research program where innovative research projects originate. In addition, congressionally directed funds for Nuclear Medicine research have been siphoned off for other purposes by the agency. To reverse this harmful trend and to restore America as the leader in this field, a substantial and steady infusion of federal funds is needed to restore growth and promise in the DOE national Nuclear Medicine research program.

- **The Society of Nuclear Medicine and the American College of Nuclear Physicians recommend a $5 million increase for the DOE Nuclear Medicine research program for FY 1990. This increase would bring the total program budget to $42.6 million in FY 1990. The Society would also recommend careful scrutiny, by the Congress, in the utilization of these funds to assure they are maximally used for their intended purposes.**

PROGRAMMATIC RECOMMENDATIONS

- We believe this Committee should encourage DOE to initiate a process to identify a workable solution to the growing restricted availability of radioisotopes that are critical for all of biomedical research and research in general.

- The Society and College understand that construction on the Center for Molecular Medicine and Immunology at the University of Medicine and Dentistry in New Jersey has not yet begun, despite the fact that Congress appropriated $7.5 million for this project in FY 1988. If this contract expires prior to the expenditure of funds for construction, the Society and College strongly urge Congress to return these funds to the base Nuclear Medicine program, rather than returning the funds to the General Treasury.

- The Society and College urge the Appropriations Committee to reexamine the wisdom of spending $5.3 million in FY 1990, as proposed by the Administration, to keep the Idaho National Engineering Laboratory power reactor in standby while the lab improves its research proposal for boron neutron capture therapy (BNCT). There are other labs across the country that are capable of and interested in performing this type of research. Since the National Cancer Institute did not favorably review the INEL project, we question why so much federal funding is put back into the project each year. The College and Society urge the Committee to restore any BNCT funds at INEL to the base Nuclear Medicine program.

- The Society and College strongly urge Congress to reaffirm commitment to the traditional peer review process in awarding federal research funds.

The Society of Nuclear Medicine and the American College of Nuclear Physicians, representing over 12,000 physicians, scientists, radiopharmacists, chemists, physicists, technologists and other professionals actively engaged in the clinical practice of and research in Nuclear Medicine, appreciate the opportunity to present our views on the FY 1990 budgetary needs of the Department of Energy's Nuclear Medicine (NM) research program.

The Society and College have submitted testimony to this Committee and others over the past six years in an effort to draw congressional attention to this worthwhile program that has been sorely underfunded in relation to the tremendous return-on-investment it has yielded over the past decade. We deeply appreciate the past support of this Committee in providing increases for the NM research program; unfortunately, however, these increases have not kept pace with inflation, and have been siphoned away to specific projects and programs outside of the base NM research program. Out of the present FY 1989 budget of $37 million, we estimate that only $24 million goes to valid Nuclear Medicine research projects.

The DOE NM research program has been at a crisis stage for several years now. Because of stagnant funding levels, research projects are being curtailed, or not started, valuable employees are being dropped, and the training of bright young investigators is dwindling. The United States was once the leader in Nuclear Medicine, but this leadership position is being surpassed by European countries and Japan, which infuse substantial amounts of funding into civilian research and development. We are also concerned that Nuclear Medicine research facilities in the United States, along with other research facilities in general, are not being maintained due to insufficient funding. Aging laboratories and equipment must be rebuilt across the nation. The more imminent danger is that the best and brightest investigators will begin to desert DOE laboratories and the field of Nuclear Medicine, and it will be difficult to recruit young scientists and physicians into the field.

The Society and College respectfully urge this Committee to take the lead in bolstering the DOE Nuclear Medicine research program by increasing its budget by $5 million in FY 1990 to a level of $42.6 million. Such an increase may seem lofty in this era of severe budgetary constraint, but it is our sincere assessment of what is needed not only to maintain, but to bolster a program that has made substantial contributions toward advancing knowledge in biological science and using this knowledge to improve medical care and hold down rising medical costs.

Medical research funding is viewed by the public as a wise investment, even in a tight budgetary environment. A 1985 OTA study reported that 79 percent of those surveyed agreed that, even in the absence of immediate benefits, "scientific research which advances the frontiers of knowledge is necessary and should be supported by the Federal government."

THE DOE NUCLEAR MEDICINE RESEARCH PROGRAM

Since the 1946 passage of the Atomic Energy Act, the Department of Energy (formally Atomic Energy Commission) has had the mandate to "conduct research and development on the peaceful use of radiation for medical diagnosis and treatment of human disease." This mandate was reinforced by President Eisenhower in his "Atoms for Peace" program unveiled in 1953. We believe that the NM technologies growing out of DOE investments in response to these mandates represent some of the greatest accomplishments of the nuclear age.

DOE support for Nuclear Medicine research is highly leveraged by working off of the basic nuclear technologies developed throughout the agency by developing instruments and procedures used in the understanding, treatment and diagnosis of disease. Research is conducted in five primary areas: stable isotope research, radioisotope development, radiopharmaceuticals, instrumentation and clinical feasibility. The multi-disciplinary research of the DOE NM research program draws upon the expertise of physics, chemistry and medicine, and is rapidly transferred to everyday clinical practice not only in Nuclear Medicine, but in numerous other fields of medicine including neurology, cardiology, oncology, hematology, gerontology, endocrinology, orthopedics, gastroenterology, nephrology and pulmonology.

Nuclear Medicine represents the safe application of radioisotopes in the diagnosis and treatment of such diseases and disorders as heart disease, cancer, stroke, Alzheimer's disease and other dementia, epilepsy, developmental disorders, mental health disorders and drug abuse. New breakthrough technologies developed with DOE support such as positron emission tomography (PET) are taking physicians to new frontiers by allowing them to assess, non-invasively, the functional metabolism, chemical processes and abnormalities of the human body long before symptoms of major diseases and disorders are even manifested. PET is allowing the development and implementation of new treatments and cures of disease.

Other DOE-supported NM research includes the development of new and improved radiolabeled tracers, the development of high-resolution PET and single photon emission computed tomography (SPECT) procedures for measuring human biological functions of the brain and heart, the refinement of imaging instrumentation, the development of effective approaches in delivering radiation therapy to cancer sites using monoclonal antibody-based radiopharmaceuticals, and clinical feasibility studies to determine the efficacy of new NM procedures in the clinical setting.

Among the most promising areas of DOE-sponsored NM research are:

Cardiac Nuclear Imaging

One of the best examples of the rapid transfer of DOE research results to the clinical setting is the use of PET to differentiate between reversible myocardial ischemia, which is treatable and myocardial infarction, which is dead tissue and therefore not treatable. Since it has been estimated that 30-40 percent of heart attack victims who receive bypass surgery do not benefit from it in terms of improved cardiac function (at a cost exceeding $9 billion per year) the usefulness of PET in selecting patients who would benefit from these costly, invasive procedures would not only improve patient care, but would yield tremendous savings.

DOE-sponsored research is also aimed at the development and refinement of SPECT, a technology that follows some of the same general principles as PET, but which is much less expensive and can be readily available in most Nuclear Medicine departments across the country. However, DOE spends only 5 percent of its operating funds on instrumentation and equipment. To help introduce state-of-the-art equipment so vital to biomedical research, more funding should be put into replacing aging equipment and to develop state-of-the-art PET and SPECT devices.

Neurologic Applications

DOE support has contributed significantly to NM research into the chemical basis of normal and disease processes of the brain. For example, PET research is providing new insights into chemical aberrations in the brain associated with Alzheimer's, Parkinson's, stroke, epilepsy, neuropsychiatric disorders, learning disorders and drug addiction. With PET, physicians are now beginning to understand the fundamental nature of these disorders, can differentiate between them, and have developed new chemical markers for selecting and improving treatment.

Cancer

DOE-supported research has yielded vast new knowledge not only in the early detection and diagnosis of cancer, but also in determining the degree and nature of the tumor non-invasively (i.e., as opposed to performing biopsies). This information guides physicians in determining the best course of treatment for different types of tumors and in monitoring the patient's response to therapy and tumor recurrence. DOE also sponsors research in cancer therapy, such as the use of radiolabeled monoclonal antibodies which localize in malignant tissues of otherwise healthy organs. Cancer research is targeted at tumors of the brain, breast, prostate and pancreas, which together afflict hundreds of thousands of people each year.

Drug Abuse

DOE also sponsors research into the neurochemical mechanisms accompanying cocaine abuse. The Brookhaven group has recently been the first to map cocaine binding sites in the living human brain with PET. UCLA has demonstrated the chemical dificiencies produced in the human brain from cocaine and amphetamine abuse. The increase in cocaine abuse, with its attendant socio-economic, legal and medical problems, was recently cited by President Bush as one of society's most urgent problems. Additional research support is needed to capitalize on the research advances in this critical area.

PROGRAMMATIC RECOMMENDATIONS

In addition to our recommendation for a $5 million increase in the DOE NM research program, the Society and College strongly believe that additional programmatic adjustments must be made to protect this relatively small but vital national resource.

First, there is now and for the foreseeable future a severe restriction in the availability of radioisotopes and radiotracers that are critical for all of biomedical research and research in general, including not only Nuclear Medicine research, but all other biomedical research and research in nutrition, agriculture, geology, astronomy or any science that requires the use of radiotracers.

The enormous DOE reactors and accelerators that currently produce these radioisotopes are not dedicated to providing a continuous, reliable supply of radioisotopes for biomedical research; therefore, these critical research materials are prepared only when other physics projects are not underway. This creates a precarious situation for investigators who must rely on an unreliable supply of this research resource. The Society and College therefore urge this Committee to encourage DOE to initiate a process to identify a solution to this problem, as it will only worsen in the coming years and is likely to require a substantial outlay of resources. The DOE should begin to address this problem now.

Second, it is our understanding that the $7.5 million appropriated in FY 1988 for the Center for Molecular Medicine and Immunology at the University of Medicine and Dentistry of New Jersey has not been expended due to legal problems surrounding the project. As the contract draws closer to its expiration, the Society and College fear that these funds, which are sorely needed in the base NM research program will be returned to the General Treasury. Since this money has already been appropriated, if unused by UMDNJ, we believe it should be transferred to the DOE base NM account to allow more vigorous support of the meritorious research projects already underway and new research ideas which are awaiting funding sources.

Third, we urge this Committee to take a leadership role in demanding accountability in the DOE NM research program. Last year, this Committee adopted report language protecting Nuclear Medicine research operating funds from internal reallocations of funds to programs outside of this account. The Society and College have not seen satisfactory DOE budgetary information detailing how scarce appropriations are spent, and would encourage this Committee to seek such information.

Finally, we respectfully urge this Committee to express its support for the traditional peer review process in the awarding of DOE research funds. Peer review ensures that scientific projects are reviewed competitively by a jury of the applicant's peers, and helps to ensure that public funds are spent wisely and judiciously.

CONCLUSION

DOE-sponsored Nuclear Medicine research has been at the forefront of exciting and important medical discoveries, yet it remains one of the lowest funded programs in the Department. Moreover, because it is not a line item in the DOE budget, we believe that congressional intent in spending appropriated funds has not been followed. Because of the enormous contributions of DOE NM research to the health of the American people, the Society and College respectfully urge this Committee and Congress to increase it's budget to $42.6 million in FY 1990, and to adopt our programmatic recommendations outlined above. This is a modest request relative to the benefit that will be derived from it. We are confident that an infusion of funds today will be returned many fold to the American public in terms of improved diagnostic and treatment capabilities, and therefore better medical care. Your support will be backed up by a grateful profession and American public.

APPENDIX II

Department of Energy
Washington, DC 20585

June 30, 1989

DOE

The Honorable James H. Scheuer
Chairman
Subcommittee on Natural Resources,
Agriculture Research and Environment
Committee on Science, Space, and Technology
House of Representatives
Washington, D.C. 20515

Dear Mr. Chairman:

On April 27, 1989, Peter N. Brush, Acting Assistant Secretary for Environment, Safety, and Health appeared before your subcommittee to discuss the Department's Fiscal Year 1990 budget authorization for Environment, Safety, and Health programs.

Following that hearing, you submitted written questions for our response to supplement the record. Enclosed are the answers to those questions.

If you have any questions, please have your staff call Michael Gilmore on 586-4277. He will be happy to assist.

Sincerely,

Robert G. Rabben
Assistant General Counsel
for Legislation

Enclosures

cc: The Honorable Claudine Schneider
Ranking Minority Member

POST-HEARING QUESTIONS AND ANSWERS
RELATING TO THE
APRIL 27, 1989, HEARING
BEFORE THE
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON NATURAL RESOURCES, AGRICULTURE RESEARCH AND ENVIRONMENT

WITNESS: PETER N. BRUSH

ACTING ASSISTANT SECRETARY FOR ENVIRONMENT, SAFETY, AND HEALTH

U.S. DEPARTMENT OF ENERGY

QUESTIONS FOR CHAIRMAN SCHEUER

Question 1: **Regarding the cleanup situation at Rocky Flats' 881 Hillside site, we have been informed that cleanup there, which was scheduled to begin this Fall, has now been delayed until 1993. It is our understanding that the Department no longer plans to carry out an interim action of processing volatile organics out of groundwater from the site.**

What is the current schedule (including start and finish dates) for cleanup at site 881? How does this schedule conform with the schedule set in the federal facility agreement signed with the EPA and State of Colorado in 1986 and the March 1988 DOE plan? What is the status of the interim action plan for processing volatile organic compounds at the site? Will the interim action plan, or the final cleanup plan include cleanup of metals and radionuclides?

Answer: The interim cleanup action for the 881 Hillside site at Rocky Flats is scheduled to begin in FY 1989. An Environmental Assessment, required by the National Environmental Policy Act, has been prepared. A Finding of No Significant Impact (FONSI) would be published in the Federal Register if the Environmental Assessment supports such a conclusion. Should this occur, the Environmental Protection Agency must approve an Interim Remedial Action Plan before actual construction can begin. EPA approval of this plan is expected.

The interim remedial actions proposed for the 881 Hillside involve construction of a French drain to intercept the flow of contaminated groundwater and treatment of the

Answer 1
(continued):

contaminated groundwater to remove the volatile organic compounds. Interim remedial actions will include the cleanup of heavy metals and radionuclides. These proposed activities would be consistent with the milestones contained in the tri-party federal facility agreement and with the agreement reached between DOE and the State of Colorado that will provide for increased State access and monitoring of the Rocky Flats Plant. Cleanup of the 881 Hillside site is expected to be completed in the year 2006.

QUESTIONS FROM CHAIRMAN SCHEUER

Question 2: **We have been informed of delays of cleanup at the Solar Evaporation Ponds at Rocky Flats. This is apparently due to the fact that the cement plant used to solidify wastes from the Ponds is now being diverted to re-solidify the pond-crete mixtures that were improperly solidified in the past.**

Answer: It is true that re-solidification of some pond-crete from cleanup of the Solar Ponds at Rocky Flats is being performed to assure integrity of the waste form. However, the Department is currently looking at means of accelerating the overall cleanup of the solar ponds, including accelerated removal of pond-crete from the site.

QUESTIONS FROM CHAIRMAN SCHEUER

Question 3: Does the Department plan to undertake any probabilistic risk analyses at the Rocky Flats Plant? If so, when, and what would the analysis consider?

Answer: Safety Analysis Reports (SARs) have been prepared and approved for all of the plutonium handling facilities at Rocky Flats. These reports were prepared using probabilistic methodologies. As we define the applicability of probabilistic risk assessments in DOE orders, we will begin to implement them at DOE facilities. These analyses will evaluate system/process operations including a detailed evaluation of human factors associated with these operations. This is important because most operations are directly controlled by the plant operators.

QUESTIONS FROM CHAIRMAN SCHEUER

Question 4: What are the Department's plans for any additional TSAs at the Rocky Flats plant this year?

Answer: A TSA of the Rocky Flats Plant was conducted in November - December 1988. The TSA report was issued in January of this year. At present, this year's plan for TSAs does not include the Rocky Flats plant.

QUESTION FROM CHAIRMAN SCHEUER

Departmental Organization

Question 5: During the hearing, Department representatives testified that the Secretary was considering a range of options regarding the organization of the Department. Is there a timetable under which this review is occurring? When will Congress be informed of the Secretary's recommendations?

Answer: The Deputy Secretary and the Under Secretary, at the Secretary's request, have been conducting a detailed assessment of the organization structures and management practices throughout the Department.

Although there is no specific timetable, this review is continuing and is expected to result in a number of significant changes with implementation extending over several months. In the meantime, actions already have been taken and currently are being implemented to establish clear and direct line management responsibilities. In furtherance of the philosophy that the Department consists of line organizations fully responsible for their own activities, it is the Secretary's intent that operational programs and activities related to environmental protection, radiation and reactor safety and worker and public health and safety be included in those responsibilities. Similarly, the Secretary has stated it is the Department's policy that compliance with environmental laws is an integral part of operating DOE facilities and that line management must be responsible and accountable for working toward compliance on a daily basis.

It is the Secretary's intention that appropriate Congressional committees be informed of changes in a timely manner.

QUESTION FROM CHAIRMAN SCHEUER

Staffing

Question 6: Representatives of the Environment, Safety and Health Program have noted that it is difficult to fill engineering, health physics, and other positions within the program, and that currently 60 positions out of 200 are vacant. Do other programs experience the same problem? If not, why not -- what are the salary or other differentials that would explain this?

Answer: First, let me clarify our recruiting efforts. We are recruiting to fill approximately 60 positions, but if we are successful in our efforts we will have gone beyond our fiscal year 1989 staffing allocation of 200 and will be well on our way to reaching our anticipated fiscal year 1990 limit of 250.

Other programs are experiencing similar difficulties in recruiting for vacant technical and administrative positions. For example, the DOE Office of Defense Programs has experienced many of the same difficulties in their recruitment for nuclear safety related positions. Recruiting is impeded and potential employees lost because of the cost of living in Washington and other high cost areas; the narrower range of benefits and lower salaries offered by the Federal Government relative to the private sector; a more cumbersome and time-consuming Federal employment process; and the extended period of time required to complete mandatory background investigations before selected applicants for certain sensitive positions can enter on duty.

QUESTIONS FROM CHAIRMAN SCHEUER

Question 7: **DOE representatives have maintained the strength of the Assistant Secretary for Environment, Safety and Health lies in that the Assistant Secretary can communicate directly with the Secretary. This direct access was a hallmark of former Secretary Herrington's tenure at DOE, and we understand that Secretary Watkins is continuing that tradition.**

Would the effectiveness of the Assistant Secretary for Environment, Safety and Health be compromised in the event a future Secretary did not allow such direct access? What authority would your office then have to do anything to effect compliance with environmental, safety, or health laws, regulations or codes?

Answer: The effectiveness of any individual who serves as an Assistant Secretary of energy could be reduced if a future Secretary did not provide that individual direct access, but direct access cannot be assured simply by enacting a provision to that effect.

Section 203 of the DOE Organization Act provides that environmental responsibilities and functions must be assigned to one of eight Presidential appointees who serve as an assistant secretary of energy. The Department consists of line organizations fully responsible for their own activities. Operational programs and activities related to environmental protection, radiation and reactor safety, and worker and public health and safety are included in those responsibilities. The Assistant Secretary for Environment, Safety and Health is assigned the responsibility for directing the development of environment, Question 7 (continued): safety, and health policy for the agency and for assuring compliance with these policies and with DOE Orders. Compliance with applicable laws related to environmental protection, radiation safety, worker safety, and those aspects of public health and safety that deal with epidemiology and radiological protection, as well as with DOE policies and directives, is assured through the audit of Headquarters program offices and DOE field organizations. Coupled with independent, outside oversight by the soon-to-be-established Defense Nuclear Facilities Safety Board and the Advisory Committee on Nuclear Facility Safety, DOE can now better assure the effectiveness of its environment, safety, and health activities without having to depend on whether a single individual has direct access to the Secretary.

ROBERT A. ROE, New Jersey, Chairman

GEORGE E. BROWN, Jr., California
JAMES H. SCHEUER, New York
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U.S. HOUSE OF REPRESENTATIVES
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
SUITE 2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515
(202) 225-6371

ROBERT S. WALKER, Pennsylvania
F. JAMES SENSENBRENNER, Jr., Wisconsin
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HAROLD P. HANSON
Executive Director
ROBERT C. KETCHAM
General Counsel
DAVID D. CLEMENT
Republican Staff Director

May 24, 1989

Honorable Peter N. Brush
Acting Assistant Secretary for
Environment, Safety and Health
U. S. Department of Energy
1000 Independence Avenue, S.W.
Washington, D. C. 20585

Dear Mr. Brush:

Several additional questions have arisen following the Department's testimony during the recent hearing on the environment, safety and health program. The Members would appreciate your taking the time to answer these questions which will be included in the record of the hearing.

1. Regarding the cleanup situation at Rocky Flats' Hillside 881 site, we have been informed that cleanup there, which was scheduled to begin this fall, has now been delayed until 1993. It is our understanding that the Department no longer plans to carry out an interim action of processing volatile organics out of groundwater from the site.

   What is the current schedule (including start and finish dates) for cleanup at site 881? How does this schedule conform with the schedule set in the federal facility agreement signed with the EPA and State of Colorado in 1986, and the March 1988 DOE plan? What is the status of the interim action plan for processing volatile organic compounds at the site? Will the interim action plan, or the final cleanup plan include cleanup of metals and radionuclides?

2. We have been informed of delays of cleanup at the Solar Evaporation Ponds at Rocky Flats. This is apparently due to the fact that the cement plant used to solidify wastes from the Ponds is now being diverted to re-solidify the pond-crete mixtures that were improperly solidified in the past.

   Is this an accurate appraisal of the status of the Pond cleanup? How long will this delay cleanup of the Ponds? What sort of waste migration can be expected during this time?

3. Does the Department plan to undertake any Probabalistic Risk Analyses at the Rocky Flats plant? Is so, when, and what would the analysis consider?

4. What are the Department's plans for any additional TSAs at the Rocky Flats plant this year?

5. During the hearing, Department representatives testified that the Secretary was considering a range of options regarding the organization of the Department. Is there a timetable under which this review is occurring? When will Congress be informed of the Secretary's recommendations?

6. Representatives of the Environment, Safety and Health Program have noted that it is difficult to fill engineering, health physics, and other positions within the program, and that currently 60 positions out of 200 are vacant. Do other programs experience the same problem? If not, why not -- what are the salary or other differentials that would explain this?

7. DOE representatives have maintained the strength of the Assistant Secretary for Environment, Safety and Health lies in that the Assistant Secretary an communicate directly with the Secretary. This direct access was a hallmark of former Secretary Herrington's tenure at DOE, and we understand that Secretary Watkins is continuing that tradition.

   Would the effectiveness of the Assistant Secretary for Environment, Safety and Health be compromised in the event a future Secretary did not allow such direct access? What authority would your office then have to do anything to effect compliance with environmental, safety, or health laws, regulations or codes?

Please furnish your written response to these questions by the close of business on June 7, 1989, so that they may be included in the hearing record. Materials should be delivered to the attention of Ms. Marty Ralston in the Subcommittee office in House Annex II, Room 388.

I appreciate greatly your testimony before the Subcommittee and look forward to working with you in the future on this issue.

With every best wish,

Sincerely,

JAMES H. SCHEUER
Chairman
Subcommittee on Natural Resources,
Agriculture Research and Environment

QUESTIONS FROM CHAIRMAN SCHEUER

Biological and Environmental Research

Question 1: The environmental problems at DOE facilities around the country have received tremendous attention. The testimony supplied by Los Alamos National Laboratory referred to plant cells which are able to accumulate large amounts of plutonium, barium, and other ground and water contaminants. What specific research projects have been undertaken recently in the Biological and Environmental Research program to address the long-term research needs of the Department? How much money is being expended on each of these projects individually?

Answer: I will be pleased to provide that information for the record.

(The information follows:)

INSTITUTION/ PROJECT TITLE	FY 1989 In Thousands
ARGONNE NATIONAL LABORATORY	
COLLOIDS-RADIONUCLIDE TRANSPORTS	$195
ORGANIC/INORGANIC COMPLEXATION PROCESSES IN SUBSURFACE ENVIRONMENTS	$80
SUB-TOTAL	$275
ARIZONA, UNIVERSITY OF	
CO-CONTAMINANT CHEMISTRY	$115
BROOKHAVEN NATIONAL LABORATORY	
MICROBIAL-MIXED WASTE TRANSFORMATIONS	$215
CALIFORNIA, UNIVERSITY OF	
COLLOIDS	$77
COLORADO, UNIVERSITY OF	
EXPLORATORY DATA ANALYSIS IN DOE SUBSURFACE MICROBIOLOGY PROGRAM	$14
E I DU PONT DE NEMOURS AND CO.	
MICROBIOLOGY OF DEEP SUBSURFACE ENVIRONMENTS	$60
EG & G (INEL)	
MICROBIOLOGY DRILLING SUPPORT	$60
DEGRADATION BY METHANOGENIC BACTERIA	$55
SUB-TOTAL	$115
FLORIDA STATE UNIVERSITY	
DEEP MICROBIOLOGY	$55
MICROSCOPICAL & CULTURAL EXAMINATION OF SUBSURFACE MICROORGANISMS	$55
SUBSURFACE MICROBIAL CULTURE COLLECTION	$30
COMPARATIVE EXAMINATION OF DEEP SUBSURFACE MICROORGANISMS	$431
SUB-TOTAL	$571
IDAHO, UNIVERSITY OF	
BIOREMEDIATION	$57
ILLINOIS, UNIVERSITY OF	
MICROBIAL ACTIVITY IN AQUIFER BIORECLAMATION	$150
LAWRENCE BERKELEY LABORATORY	
THERMODYNAMIC PROPERTIES OF CHEMICAL SPECIES	$63
LAWRENCE LIVERMORE NATIONAL LABORATORY	
SUBSURFACE TRANSPORT OF ORGANICS	$40
CHEMICAL FLOW ANALYSIS USING FIBER OPTICS	$150
CHEMICAL-MICROBIOLOGICAL PROCESSES	$200
PARTICLE METHODS IN TRANSPORT	$55
SUB-TOTAL	$445

INSTITUTION/ PROJECT TITLE	FY 1989
LOS ALAMOS NATIONAL LABORATORY	
CO-CONTAMINANT REACTION CHEMISTRY AT INTERFACES	$65
MASSACHUSETTS INSTITUTE OF TECHNOLOGY	
COLLOIDS	$150
MICHIGAN STATE UNIVERSITY	
INFLUENCE OF SORPTION/DESORPTION PROCESSES ON BIOAVAILABILITY OF ORGANICS	$100
MICHIGAN, UNIVERSITY OF	
MULTIPHASE R	$180
MULTIPHASE	$150
BIOREMEDIATION	$50
SUB-TOTAL	$380
MISSOURI, UNIVERSITY OF	
FIELD RESEARCH	$60
NATIONAL ACADEMY OF SCIENCES	
CORE SUPPORT OF WATER SCI & TECH BOARD	$15
NEW MEXICO, UNIVERSITY OF	
RESEARCH SUPPORT	$227
PREDICTIVE METHODS	$148
SUB-TOTAL	$375
OAK RIDGE ASSOCIATED UNIVERSITIES	
SUBSURFACE INITIATIVE	$84
OAK RIDGE NATIONAL LABORATORY	
MICROBIAL TRANSPORT	$10
EXPERT SYSTEM	$150
EXPERIMENTS USING NATURAL ORGANICS	$330
SOIL-WATER INTERACTIONS CONTROL ON CONTAMINANT RELEASE & TREATMENT	$55
SUBSURFACE MODEL VALIDATION IN HETEROGENEOUS FIELD SOILS	$63
SUB-TOTAL	$608
OKLAHOMA, UNIVERSITY OF	
ENUMERATION & ECOLOGY OF SELECTED ANAEROBIC BACTERIA	$50
OREGON STATE UNIVERSITY	
CO-CONTAMINANT CHEMISTRY	$125
PACIFIC NORTHWEST LABORATORY	
MICROBIOLOGICAL PHENOMENA	$680
RADIONUCLIDE ORGANIC COMPLEXING	$295
INTERMEDIATE CO-CONTAMINANT INTERACTIONS	$340
POREWATER CHEMISTRY	$130
FLUID DYNAMICS IN SUBSURFACE SYSTEMS	$300
SUBSURFACE CHEM/ORGANIC EXPERIMENTS	$575
SUB-TOTAL	$2320

INSTITUTION/ PROJECT TITLE	FY 1989
PENNSYLVANIA STATE UNIVERSITY	
ANAEROBIC MICROBIAL ACTIVITY IN THE DEEP SUBSURFACE	$110
SURFACE HYDROLOGY, SEDIMENT TRANSPORT DYNAMICS	$90
PRINCETON UNIVERSITY	
BEHAVIOR OF NON-AQUEOUS PHASE ORGANIC CONTAMINANTS IN MULTI-AQUIFER SYSTEMS	$50
HYDROPHYSICAL PROCESSES IN THE SUBSURFACE	$30
SUB-TOTAL	$80
PURDUE UNIVERSITY	
SUPERCOMPUTER SIMULATION OF CLAY-ORGANIC-WATER-INTERACTIONS	$170
TENNESSEE, UNIVERSITY OF	
MICROBIOLOGY SUBSURFACE ENVIRONMENTS SAMPLE PROCUREMENT PROPOSAL	$89
PENDING AWARDS	
SUBSURFACE INITIATIVES	$76
VIRGINIA, UNIVERSITY OF	
BIOREMEDIATION	$80
WISCONSIN, UNIVERSITY OF	
PHYSICAL-CHEMICAL MECHANISMS & VARIABLES WHICH AFFECT TRANSPORT	$90
TOTAL	$7274

QUESTIONS FROM CHAIRMAN SCHEUER

Biological and Environmental Research

Question 2:	Admiral Watkins has announced that the Department will rely on the national labs to come up with innovative solutions in the areas of hazardous waste management. The Secretary has given Congress an August timetable for developing a report on this matter. How much of the research in this area will be underwritten by the BER program? Will you require additional funds to meet an expanded research capability in this area? If indeed, this research is not the responsibility of the BER program, please indicate which program currently and will in the future bear this responsibility.
Answer:	The BER program is developing a research plan targeted on reduction of costs and waste cleanup in the mid- to long-term (10 years and more). The BER program has been, and will continue to be, targeted on the long range needs of the Department in fundamental research on waste related problems. The plan being developed for the Secretary is for near-term (up to 5 years) waste clean-up. This plan will address the more immediate needs of the Department to characterize and prioritize all cleanup activities at DOE sites. This plan will encompass waste management operations, inactive waste site cleanup, and corrective actions needed for all DOE operating facilities. In FY 1988, the Office of Energy Research recognized the need to accelerate research in groundwater contamination and waste problems at DOE sites. Research funds increased from $3.5

million in FY 1988 to $7.3 million in FY 1989. A solicitation was published in the Federal Register and with the enhanced funding in FY 1989, 22 new research awards were made from highly competitive proposal submissions. Thirteen awards went to universities and nine went to national laboratories. A budget level of $11.8 million for operating expenses and $1.8 million for capital equipment has been requested for FY 1990 and is anticipated to cover the immediate needs of the Department's research in this area for FY 1990.

APPENDIX III

Statement of J. Allen Wampler
Assistant Secretary for Fossil Energy
Department of Energy
before the
Committee on Science, Space and Technology
Subcommittee on Natural Resources, Agriculture Research
and Environment

April 27, 1989

Mr. Chairman and Members of the Subcommittee:

As part of its fiscal year 1990 budget proposal for Fossil Energy-related programs, the Department of Energy is requesting $1.050 million for the Liquefied Gaseous Fuels Spill Test Facility (LGFSTF) program. The facility serves as a "test bed" for both industry and government in developing safety guidelines for the handling of liquefied gaseous fuels and other toxic liquids should they be accidentally released during commercial transport, manufacturing, or storage.

FACILITY DESCRIPTION

Located on the Frenchman Flat Basin at the the Nevada Test Site, the facility was completed in December 1985 and has been used for three successive test seasons. This site was selected both because of its remote location and because of the predictability of wind patterns during certain parts of the year. The test "window"--a time when actual spills can be conducted as dictated by local weather patterns -- opens in April and extends through September. This typically allows for the conduct of two to three series of tests, depending on the specific plans of the sponsors.

The facility consists of a control building housing data acquisition and recording instruments, a command and control computer, a tank farm and related spill area. During 1988, an induced draft wind tunnel, a spill pad, and a safety building were added through approximately $1.8 million of funding by private sponsors who needed specialized capabilities. The wind tunnel has a working chamber that is 8 feet wide by 16 feet high and 96 feet long. It has the capability to vary temperature, humidity, spill rate, and spill volume. These new facilities have been retained for future use, and title is being transferred to DOE at a minimal cost.

The facility has been designed to satisfy the need for information on risk assessment, emergency response, regulation, plant design, plant siting, and hazard mitigation where potentially hazardous liquids are involved. It is capable of spilling up to 53,000 gallons of cryogenic fluids, such as refrigerated ammonia, in two minutes. In addition, up to 24,000 gallons of ambient temperature materials, such as chlorine, can be released in five minutes. The sensor and data acquisition system is available to acquire data on spill characteristics such as rate, volume, temperature, and pressure; downwind gas concentration and aerosol characteristics; meteorological parameters; and blast or fire effects.

Spill rate and duration, as well as test condition parameter checks, occur under computer control from the control building.

The Department's principal role is to operate and maintain this facility in a safe and environmentally sound manner. Test sponsors, whether from the private sector or from other public agencies, submit plans for using the facility for review by the Department, and sponsors reimburse the Department for the incremental costs of testing plus any cleanup necessary to prepare the facility for the next user.

USERS AND POTENTIAL USERS

The objective of the Liquefied Gaseous Fuels Spill Test Facility is to give both private and public sector users the technical data they need to better protect the public from the potential health and safety hazards posed by a spill of liquefied gaseous fuels or other toxic and hazardous fluids. The Department has conducted an aggressive outreach effort to alert potential users to the availability of this one-of-a-kind test facility. This effort has extended both to domestic and international organizations that have an interest in and need for safety-related data on liquefied gaseous fuels or toxic and hazardous chemicals.

During 1986, tests funded by Amoco Oil Corporation were conducted to obtain downwind concentration measurements for hydrogen fluoride gas. The data has been utilized to assist in verifying atmospheric dispersion models. The test series consisted of six tests which examined downwind concentrations when hydrogen fluoride was released in a horizontal jet and the mitigation effects of various water-spray systems in controlling downwind dispersion. The value of these tests to industry is indicated by follow-on work in 1988, as discussed below.

In the 1987 test season, experiments were conducted for the Gas Research Institute and the Department of Transportation. These tests evaluated the effectiveness of "vapor fences" in mitigating the accidental release of liquefied natural gas at peak shaving plants. The test scenario was comprised of six large-scale releases of liquefied natural gas; the acquired data is being used to validate wind tunnel simulations of vapor fence effects on heavy gas dispersion. Once validated, the wind tunnel models will be used to determine the vapor fence performance for several different accident scenarios.

During 1988, two test sponsors used the LGFSTF: Chubb National Foam, Inc. and the Mobil Research and Development Corporation (MRDC) acting as the Technical Representative of the Joint Industry Hydrogen Fluoride (HF) Mitigation Study Group. The study group was comprised of 21 organizations who manufacture, transport, store and/or use HF.

The Chubb National Foam effort consisted of nine tests to determine the effectiveness of three aqueous foams in suppressing vapor releases from spills of Chlorine, Sulfur Dioxide, Monomethylamine, Phosporous Trichloride, Phosphorous Oxychloride, Anhydrous Hydrogen Fluoride, and Bromine.

The MRDC series of tests addressed the effectiveness of various water spray configurations under controlled conditions in the wind tunnel as a tool to effectively mitigate sudden releases of HF to the atmosphere. A total of 87 releases were accomplished during a six week testing period, using the wind tunnel built by MRDC.

During the 1988 test season, the Department permitted simultaneous activities at the site: The MRDC conducted construction activities on the wind tunnel during the early part of the day, while Chubb National Foam used the spill pad during the afternoon, when the winds were favorable for testing.

In 1987, the Department entered into a Memorandum of Understanding with the Environmental Protection Agency (EPA) and the Department of Transportation to support a collaborative research and development program involving hazardous substance spills to be conducted at the LGFSTF. The agreement allows the agencies, in collaboration with the private sector and other government organizations, to develop, structure and prioritize the objectives of a generic national research and development program germane to heavier-than-air gas dispersion, hazardous substance releases and related mitigation technologies. As directed by Congress, the Department has contracted with the Western Research Institution to provide technical and analytical support for the collaborative effort.

In FY 1989, the Department entered into a collaborative research and development effort with the Center for Chemical Process Safety (CCPS), a directorate of the American Institute of Chemical Engineers, to study the formation of aerosols in the accidental releases of toxic or hazardous liquids utilizing the wind tunnel at the LGFSTF. Representatives of the EPA and the Department of Transportation agreed with the Department that this Aerosol Research Project is of high priority and of mutual interest to our three agencies. EPA and private funds are being used for preplanning and management of the series of tests, and the Department has agreed to use a portion of the LGFSTF funds appropriated in FY 1989 to defray some of the test costs. The CCPS is responsible for developing the specific test plan and adhering to the Department's safety and environmental guidelines.

In addition, in FY 1989 the Department is working with the American Petroleum Institute to provide a user friendly version of the DEGADIS (Dense Gas Dispersion) model for use on a personal computer. The Department's portion of the effort is intended to ensure that the resulting model is consistent with the existing DEGADIS model developed and refined by the EPA and the Coast Guard in prior years. We will also support installation and testing of the PC version at the LGFSTF.

These interagency and public/private cooperative activities with the CCPS and the API exemplify the types of projects that the Department is seeking for the LGFSTF program.

At present, the Department has approved a request from ANSUL Corporation to use the facility in FY 1989 to test the effectiveness of non-aqueous foams developed by ANSUL as mitigation agents in suppressing vapors from acidic liquids and acidic gaseous liquids. The Department is also working with other parties who have indicated an interest in sponsoring tests in the 1989 and 1990 seasons.

FY 1990 BUDGET PROPOSAL

The $1.050 million requested for fiscal year 1990 will provide for program continuity. The funds will provide for the management and maintenance of the LGFSTF physical plant, the continuation of facility baseline operations support, and continued technical interaction with potential sponsors of research. They will also provide for the administrative and scientific support required to review test proposals and provide test cost estimates. As in the past, appropriated funds will be supplemented by user fees for the incremental costs of testing.

Also the funds requested will provide for the continued support of the DOE/EPA/DOT collaborative long-range research and development program.

CONCLUSION

There is a growing public awareness of the risks associated with the Nation's large-scale commercial activities involving the storage and transportation of pressurized, liquefied gaseous fuels and high vapor pressure chemicals. The need for effectively and efficiently gaining further knowledge on dispersion, impact, and mitigation of released liquefied gases requires the coordination of the activities of a number of Federal agencies, such as the EPA, the Department of Transportation, Department of Defense agencies, and the Department of Energy, with those of private industry. The LGFSTF responds to this this need by providing an arena in which these entities can cooperatively pursue their mutual interests and extend the capability of the original facility to meet a broader range of testing requirements, as necessary. Given its capability for handling high vapor pressure and other potentially hazardous fluids, the facility is a national asset that is making an important contribution to equipment standards, safety and control issues, and industrial regulations. The FY 1990 budget proposal will continue the progress which has been achieved in this area in recent years.

TESTIMONY

Submitted to the

House Natural Resources, Agriculture
Research and Environment Subcommittee
of the
Committee on Science, Space, and Technology

on

April 27, 1989

by

Dr. Ronald P. Koopman
Lawrence Livermore National Laboratory
P.O. Box 808, Livermore, California 94550

The Need for a Coordinated Federal Research Program on the Accidental Release of Hasardous Materials into the Atmosphere

The Problem

As the manufacture, transportation and use of hazardous materials increases, so are the number of serious accidents occurring worldwide within the chemical industry. Each year, over 200 chemical accidents occur causing significant damage to human health, environment, and property. There have been 10 major chemical accidents in the last 14 years, the worst of which was the methyl isocyanate release at Bhopal, India in 1984 in which nearly 3000 people were killed and as many as 200,000 people injured.

Lack of knowledge about what actually happens when a hazardous material is released into the atmosphere creates a weak link in the network which protects us from exposure to hazardous chemicals. If the agencies responsible for public safety and the industries themselves do not fully understand the consequences of an accidental release, they may not devote enough resources to protecting workers and the public from the potential problem. Recently, the Congressional Office of Technology Assessment (OTA) has determined that human error and lack of information and advance planning, as opposed to equipment failures, were the cause of most accidents and spills. Phasing out of several federal agency research programs (Department of Energy (DOE), U.S. Coast Guard) over the last eight years has left a void and a clear need for long-term research in this multi-disciplinary area.

During this period, industry has tended to focus on short-range, near-term needs. They have generously supported work to solve very specific problems and have supported ongoing research for particular chemicals (LNG and hydrofluoric acid (HF), for instance). However, it was the long-range government-sponsored research which uncovered many of the problems currently being worked on in the first place and which created much of the information and the products currently being used in the industrial safety programs.

The History

Lawrence Livermore National Laboratory is managed for the DOE by the University of California. DOE initiated the Liquefied Gaseous Fuels (LGF) Program at Lawrence Livermore National Laboratory (LLNL) in 1977 to do the research necessary to understand and deal with the hazards associated with liquefied natural gas (LNG). Tests with LNG occurred in 1978, 1980, 1981, and 1987. In 1980 and 1981 the program was receiving approximately $4 million per year from DOE to conduct this research. The scope of the program was broadened to include other denser-than-air hazardous materials around 1980 as the scientific basis and national need for this research became better understood. At the heart of the work was the new scientific field of dense-gas dispersion in the atmosphere.

In 1982, DOE decided to terminate the program while at essentially the same time Congress, mandated construction of a permanent spill test facility. LLNL provided the conceptional design for the facility which was completed by DOE, at the Nevada Test Site, in 1986. With funding from Gas Research Institute and DOT, LLNL conducted large-scale (LNG) tests at the facility in 1987. LLNL has also conducted large-scale atmospheric dispersion experiments with nitrogen tetroxide (N_2O_4), sponsored by the U.S. Air Force, very large ammonia (NH_3) experiments sponsored by the U.S. Coast Guard and The Fertiliser Institute, and two series of HF experiments sponsored by Amoco and by a consortium of petroleum and chemical companies.

The LLNL program has, in the past, involved complementary work both in (1) mathematical modeling of the important physical and chemical phenomena active during the release of a denser-than-air cloud into the atmosphere, and (2) large-scale, intensively instrumented field experiments to obtain the basic data necessary to develop and validate the models and to understand the important phenomena well enough that hazard mitigation approaches can be developed and verified. The modeling has provided the motivation for unique field experiments and has been useful in their planning, and their understanding. And, of course, recently the models have become a powerful resource being used by industry and others in predicting the consequences of various kinds of accidental releases.

Many hazardous chemicals behave as dense gases if accidentally released. Some of the worst problems come from materials stored or used under pressure and above their boiling point, which flash to vapor and fine aerosol droplets when released. These dense clouds spread by gravity, follow terrain features, become decoupled from the atmosphere and are not easily diluted by ambient air. They travel and remain hazardous for long distances downwind. Conventional air pollution modeling ignores these effects and can drastically underpredict the gas concentrations at long distances downwind. For example, LLNL ammonia data showed instantly-lethal concentrations two miles downwind. These concentrations were ten times higher than the air pollution models predicted.

In conjunction with the field tests, LLNL has developed two state-of-the-art dense-gas atmospheric dispersion models called FEM3 and SLAB which are in widespread use by many organizations and which provide the best and most complete physical description of dense-gas dispersion in the atmopshere. These models were originally developed as part of the DOE research program. Support to continue that development work has come from the U.S. Air Force, the U.S. Army, and the American Petroleum Institute after DOE support ended. Thus, the early research investment has paid off well in the form of useful and much-needed products and information.

The field experiments have identified new phenomena, such as turbulence damping, which must be included in the models, and serious potential hazards which were either unknown or ignored by both industry and regulators in the past. The importance of flashing, two-phase flow and aerosol formation when HF or ammonia are released was largely unacknowledged prior to our 1983 ammonia experiments and our 1986 HF experiments. The HF work has prompted the petroleum and chemical industries to create a large ad hoc cooperative program to develop better data, improve mathematical models, and to develop and evaluate mitigation methods for HF releases. However, the industry HF program is temporary, and will deal only with the immediate issues surrounding HF. The experiments in general have also produced a valuable data base of dense-gas dispersion data which is being used to validate models.

Unfortunately, the reduction of Federal funds has severely impacted the ability of the dense-gas research community to continue with scientifically meaningful field testing. For example, funding from DOE for the LLNL LGF Program has dropped from $3,300,000 in

1982 to $100,000 this year with $0 proposed for 1990. As a result, the LLNL experimental team has been disbanded.

In the course of the last ten years, we at LLNL in the U.S., and Shell and British Health and Safety Executive in Europe, have developed most of the information which exists on what happens when these materials, or materials which behave similarly, are released into the atmosphere. Much progress has been made in our understanding of what happens during an accidental release, but the problem is enormously complicated and not all of that understanding has been incorporated into even the best current models. Even less of the results of these programs have found their way into the regulatory or emergency response organisations, into measures which help mitigate the hazard from accidental spills and to improve understanding of chemical hazards in the general public. Active Federal agency participation is necessary to insure that the improved technology is incorporated into mitigating the effects of chemical accidents, and if the necessary additional long-range research required to improve our understanding of dense-gas dispersion is going to be performed.

The Research Needs

1. Atmospheric dispersion model development

- An emergency response capability which can handle dense-gas releases in complex terrain with variable winds is badly needed. No such capability now exists.
- Since most models are applied to real-life situations involving complex plant structures and complex terrain, improvements in understanding and turbulence modeling are needed to deal with these complexities realistically.
- Some accidental releases produce aerosols which increase the hazard. For ammonia and HF, for instance, aerosols make up about 80% of the release mass and help keep the cloud cold, "ground-hugging", and dense as it travels downwind. More realistic aerosol models are needed to include reactions with water vapor, ground deposition, and removal by water spray. An assessment of the potential for the formation of aerosols for commonly-used hazardous chemicals is needed so that their accidental release hazard can be adequately assessed. For example, the amount of aerosol formed during chlorine releases is still unknown, and phosgene is another candidate for analysis and field testing.

2. Atmospheric dispersion model evaluation

- Many dispersion models are currently in use which do not treat denser-than-air gases, mixtures of aerosol and vapor, or other known effects associated with the accidental release of hazardous materials. Errors of a factor of 10, and in at least one case of a factor of 300, are known to exist because of use of inadequate dispersion models. This means that planners and emergency responders could be seriously misled by the current poor, unverified information. Very little systematic evaluation of dispersion models has been done and most of what has been accomplished was performed by the model developer and is not a complete or independent evaluation. Further development of a rigorous, standardised methodology for dense-gas model evaluation is needed. This effort should include the application of this methodology to all current dense-gas dispersion models using the data from the various dense gas field experiments.

- Since dense gas releases flow by gravity in the absence of strong winds, dense gas dispersion studies in complex terrain where gravity flow dominates are needed. This information would then be used to evaluate models for dispersion in complex terrain.

3. Hazard Mitigation

- Very little research has been done in this country on hazard mitigation systems such as water sprays and vapor barriers. A research program in hazard mitigation should be established.
- Once hazard mitigation systems have evolved through research and development, prototype systems at near full scale should be evaluated at the DOE's Nevada Spill Test Facility.

4. Monitors

- There is an ongoing need for reliable sensors for the various hazardous chemicals.

5. Analysis

- A very large investment has been made in the various large-scale field tests conducted over the last 10 years. Not nearly enough has been devoted to analysis of those results. An ongoing analysis effort would not be costly and could produce significant additional benefits.
- Data from past tests and mathematical models need to be put into a form that is usable by the Local Emergency Planning Committees (LEPC's) mandated by the 1986 Emergency Planning and Community Right-to-know Act (SARA Title III). This effort should also include developing appropriate risk analysis methods for large-scale accidental chemical releases.

6. Combustion

- Many accidental toxic chemical releases are accompanied by fire or explosion. In some cases this mitigates the toxic gas hazard. However, if the flame front accelerates to detonation velocities, the explosion hazard could be more damaging. Further work on combustion effects associated with large scale releases is needed.

7. Health Effects

- It is necessary to continue to analyse and improve the toxicological effects data base for the various chemicals of concern.

8. Technology Transfer

- In order for this applied research to be useful, it must be conveyed to the various Federal agencies, industries, state and local authorities, and LEPC's. This will involve interpretation of research results and judgement based on sound scientific knowledge. It will also be a large effort because of the widespread interest and need for this information.

A Federal Research Program

Only the Federal agencies are in a position to conduct the long-range, multi-disciplinary research needed in this field. This program must be coordinated among the various Federal agencies, most of whom have a well-defined research, safety, or regulatory interest, as well as industry, and state and local authorities. All of these entities require good information and proven analytical tools in order to make sound decisions. A properly balanced, funded and managed research program would provide these. Current Federally-sponsored research work is nearly non-existant. Except for HF work, development of industry-sponsored programs has also essentially stopped because of lack of Federal agency involvement. Both the chlorine and phosgene industries have put their test plans on hold because of lack of interest from the Federal agencies.

We have recently briefed the Subcommittee on Atmospheric Research (SAR) of the Federal Coordinating Council for Science, Engineering, and Technology on our research program. The SAR is composed of members from NSF, DOA, DOC, DoD, DOE, EPA, and NASA. The SAR members recognized the need for continued Federal agency work in this area and are very interested in the program. The chairman, Dr. Eugene W. Bierly, NSF, is currently developing plans among the agencies for continued coordinated work in dense gas dispersion. Since the interest in and needs for this work are widespread among the several federal agencies, the SAR may well play the key role of coordinating the various agencies (to ensure completeness and reduce duplication) and of deciding on research priorities. LLNL has developed close ties to industry and many state and local authorities all of whom are intersted in our research results and mathematical models. LLNL has the scientific basis for conducting the relevant research, develop the needed information, and interacting technically with all of these organizations as part of a Federally funded research program in dense-gas dispersion and accidental release of hasarous materials. Should Federal funding be made available, LLNL would be a willing participant in such a program.

ENVIRONMENTAL POLICY INSTITUTE

STATEMENT FOR THE RECORD BY
FRED MILLAR, PH.D.
DIRECTOR, TOXIC CHEMICALS SAFETY AND HEALTH PROJECT
ENVIRONMENTAL POLICY INSTITUTE/FRIENDS OF THE EARTH/
OCEANIC SOCIETY

FOR THE SUBCOMMITTEE ON NATURAL RESOURCES,
AGRICULTURAL RESEARCH AND ENVIRONMENT,
HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

APRIL 25, 1989

I appreciate the opportunity to submit a statement for the record on the subject of programs within the Department of Energy's FY 1990 budget request, and specifically on the future of the multi-agency Liquified Gaseous Fuels Program, currently housed at the U.S. Department of Energy. My statement is being submitted on behalf of the 15,000 members and supporters of the Environmental Policy Institute and Friends of the Earth and the 30,000 members of the Oceanic Society.

These three national environmental organizations recently merged to form a global environmental advocacy organization, working with regional and local citizens groups on an array of environmental concerns around the world. I have worked on issues involving hazardous chemicals for the past ten years and have testified before numerous state and local legislative bodies as well as before committees of the U.S. Senate and of the House of Representatives.

INTRODUCTION

In the 1987 Energy and Water Appropriations Bill, Congress directed DOE to establish a collaborative research program with DOT and EPA and spend about $1 million per year conducting hazardous materials spill research on a continuing basis. DOE, DOT, and EPA have signed a Memo of Understanding but essentially nothing was spent on research. Again, in the 1989 Energy and Water Bill, the DOE budget request was increased to $1,500,000 with direction to provide "facility maintenance, research and development and technical interaction with potential sponsors of research". Very little has been spent on research.

218 D Street, S.E., Washington, D.C. 20003 (202) 544-2600

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We urge the Congress this year (1) to shift direction of the spill research program, from the DOE-multiagency scheme which has produced such little result, to EPA as the lead agency, while leaving the physical maintainance and operation of the spills test facility within the DOE, and (2) to specify a process and method by which EPA shall consult an independent advisory group which will help set the research and public information dissemination priorities for a ten-year multi-agency program, using the relevant national laboratories with experience in such research and funded by the federal agencies and the industries producing or handling the chemicals to be tested.

EPA has responsibility to deal with chemical accident prevention. EPA has tried to establish a funded research program in accidental release for the last three years, but has failed to get approval by the Administrator. This, in spite of a recent EPA study which indicated that accidental release of toxics is an area of high risk but low EPA effort, a situation which should be remedied. DOT has helped fund LNG tests at the facility, but is not bringing any funding to the collaborative research program.

The U.S. Air Force sponsored the N2O4 tests in 1983 and has provided ongoing support for dispersion model assessment, model development and improvement, and model validation. This, along with funding from the U.S. Army has allowed continuation of research in this field.

In recent years, the researchers have come to rely on industry for more and more of their support. The Fertilizer Institute and the American Association of Railroads helped sponsor the ammonia tests. Amoco sponsored the Hydrogen Fluoride (HF) tests, and Gas Research Institute provided most of the funds for the 1987 LNG tests. American Petroleum Institute is providing funding for model development. In recent years, however, industrial test sponsors have dropped out, in part because of lack of interest on the part of the Federal agencies. For several years, The Chlorine Institute and the Chemical Manufacturers Association Phosgene Panel were planning test programs badly needed to answer technical questions. Neither organization is currently willing to go ahead with what could prove to be alarming tests at this time, in part because of the high cost and lack of Federal interest and involvement.

Many of the research findings generated by the spills test program have been shocking to the sponsoring industry, and may have dire implications for the current siting of very dangerous chemical facilities near populated areas. And despite some interest by the American Institute of Chemical Engineers, there is no ten-year or even five-year plan for orderly progress of research in the areas most badly needed. We do not feel that further voluntary industry commitments can be securely counted on for future toxic gas dispersion research, when so much of that research has resulted in stunningly "bad news" for the industries.

A separate problem is that the bad news learned from the tests has not been quickly and effectively shared with citizens and public officials with a need to know, for example, citizens and emergency response officials surrounding HF facilities and along transportation routes for N2O4 cargoes. A strong federal program is necessary to make sure crucial and new information on toxic cloud dangers is disseminated rapidly and effectively to those at highest risk in the U.S. and abroad.

BACKGROUND

The Liquefied Gaseous Fuels program is run by DOE. Since 1977, research into the consequences of large scale accidental releases of hazardous and toxic materials, such as liquefied national gas (LNG), ammonia, nitrogen tetroxide, and hydrogen fluoride has been performed by Lawrence Livermore National Laboratory within this program. The program has provided key safety information on these materials which has been important to industry and Federal, State, and local agencies. In 1982, Congress appropriated funds and directed DOE to build a hazardous materials spill test facility and at about the same time, COE decided to terminate the research program. In 1986 Congress directed DOE to establish a research program at this facility in collaboration with EPA and DOT. The facility had hardly been completed when DOE began proposing to terminate the research program and eliminate support for operations and maintenance.

TESTING HISTORY

The LGF Program was created by DOE to address the safety issues associated with large-scale use of liquefied natural gas (LNG). It was subsequently broadened to include other fuels and hazardous chemicals. Mathematical models were developed to predict the consequences of large-scale accidental releases of these materials and test were conducted to validate these models. Tests with liquefied natural gas were conducted in 1978, 1980, and 1981 under DOE sponsorship. In 1983 Congressionally mandated large-scale ammonia tests were conducted under sponsorship of the U.S. Coast Guard and the Fertilizer Institute. The U.S. Air Force sponsored N2O4 spill tests also in 1983. In 1986 Amoco, Mobile, DuPont, and Allied sponsored hydrogen fluoride (HF) tests. In 1987 Gas Research Institute and DOT sponsored LNG vapor barrier mitigation tests. Followup wind-tunnel tests were conducted with Hydrogen Fluoride in 1988. LLNL provided scientific direction and analysis and conducted all of these experimental programs.

The program has accomplished a lot so far toward solving the problem of accidental release of hazardous materials. It is still a major national problem, however, and there is still a lot of work to do. We have attached materials for the record indicating the vital public policy interest in denser-than-air toxic cloud problems in the U.S.

INDUSTRY PARTICIPATION

Since 1983 most of the testing has been industry sponsored. Unfortunately, two potential sponsors, the Chemical Manufactures Association Phosgene Panel and the Chlorine Institute, are experiencing difficulties getting unanimous approval from their corporate members to proceed with tests at the LGF facility. They say that the problem is that they do not have "a regulatory gun at their heads," and there is competition for money. On the positive side, the HF results so startled the oil and HF industries that they are have conducted additional HF testing. Exxon and Texaco have joined Amoco, Mobil, Allied, Dupont and others (20 companies) to create a potentially powerful HF interest group which is funding additional research on HF.

Oak Ridge and DOE contractors who handle UF6 are also possible future participants since the hazard from a UF_6 release is the HF formed upon reaction with atmospheric water vapor. This was the culprit in the recent accident at Gore, Oklahoma. Once again, the problem is money. The uranium enrichment side of DOE has had budget cuts.

Cooperative work and funding from industry will not continue if there is no ongoing research program which can keep the current problems associated with large-scale accidental releases in the atmosphere in front of those organizations (mostly industrial) who own the problem. The severity of the problem associated with large-scale HF releases was essentially unknown to the management of the various major oil and chemical companies until the tests were conducted. Concern within these major corporations over HF safety has become widespread, and with it a willingness to spend money to do something about the problem has appeared.

WHY GOVERNMENT SPONSORED RESEARCH IS IMPORTANT

The government role is still not well defined, and LLNL continues to be essentially the only organization conducting research in the field. There are many commercial organizations which use others' research results to provide information and advice to industrial clients, but none of them do research. Getting research initiatives funded is difficult because many of the topics are broader than the interests of the trade associations or industries which would provide funds. **Support of the broad based research need is where government has a role.** This should create a productive synergism between government and industry in this field. Instead, DOE is trying once again to cancel the program.

There is an immediate need for the research program. Much of the spill data, taken since 1983, has still not been adequately analyzed because of lack of funding. **It is crucial that the findings from the testing and research be communicated to the proper government authorities, concerned industries, and communities if the nation is to benefit full from this work** Outside organizations are clamoring to use LLNL's mathematical dispersion models but require better documentation. In addition, the models need improvements based on what has been learned in the recent tests. This is another activity which should be supported by a research program.

A successful testing program must be embedded in a research program for technical reasons as well. Research findings provide the reason for testing. Corporate safety managers need good reasons to pry loose the large amount of money necessary to fund a major test program. Testing will, in turn, promote further improvements in the theory and computer models, additional lab scale tests, and wind tunnel work which will eventually lead back to more field testing until this problem is solved. If the spiral is broken, progress stops unless other organizations are able to fill in. Progress is currently sputtering to a standstill. In the past **DOE has said that they have eliminated all research from the LGF Program.** Very few others are doing research in this field, and it is badly needed. The ammonia and HF result have been shocking to the scientific and industrial communities and to the industry. Satisfactory theories and basic knowledge do not exist in many areas of this field. Some of the information needed is in the unanalyzed ammonia data.

BUDGET PROBLEMS

DOE has interpreted the 1987 Energy and Water Developmant Appropriations Bill language:

> "... develop a Memorandum of Understanding with EPA and DOT establishing a long-range plan for collaborative research at the Liquefied Gaseous Fuels Spill Test Facility (to be funded at about $1,000,000 per year)" and"... to continue to provide baseline operations support for facility maintenance and technical interaction with potential sponsors of research." (at about $500,000 per year)

very rigidly such that data analysis, model development, and general research into accidental release and dense gas dispersion are not acceptable. Thus in spite of the Congressional direction and various appropriated funds, the program has constantly been in trouble with DOE. Congressional action was needed in the past to keep the program alive. The following table demonstrates why Congressional help is needed to continue this research.

DOE FUNDING HISTORY ($1000)

Fiscal Year	LLNL LGF Program	
1978	1156	Avocet Tests (LNG)
1979	1400	
1980	4400	Burro Tests (LNG)
1981	3700	Coyote Tests (LNG)
1982	3300	
1983	1000	(+500 from Gas Research Institute)
1984	2232	includes facility construction
1985	2290	includes facility construction
1986	1304	includes facility construction
1987	678	
1988	150	
1989	100	
1990	0	proposed

Research in the field of accidental release is coming to a halt because the Federal agencies are not providing adequate funding to continue the work. Immediately after the Bhopal accident, a study by the Congressional Research Service found that there are no U.S. regulations on chemical plants designed to prevent the accidental release of hazardous chemicals. They also concluded that at minimum, the federal government should have a role in research and data collection. The federal government has made no move to fill that role; rather, it is moving to eliminate all current participation. Without firm and quick action by

Congress, the LLNL research program, the only denser-than-air dispersion research program involving field-scale experiments in the U.S., will collapse, and much of the knowledge and progress to date could be lost.

Attachments: California State Senate and Texas City HF release documents
N2O4 shipments controversy

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